VOL. XXII. JULY, 1906.

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FOURTH SERIES

VOL. XXII—[WHOLE NUMBER, CLXXII.]

No. 127—JULY, 1906.

WITH PLATE I.

NEW HAVEN, CONNECTICUT.

1906

THE TUTTLE, MOREHOUSE & TAYLOR CO., PRINTERS, 123 TEMPLE STREET.

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THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. I.—*The Relative Proportion of Radium and Uranium in Radio-Active Minerals;* by E. RUTHERFORD and B. B. BOLTWOOD.

IN the July number for last year of this Journal, the writers gave an account* of measurements which had been made to determine the amount of radium present per gram of uranium in a natural mineral. Since previous experiments had shown that the amount of radium in a mineral was always proportional to its content of uranium, it was pointed out that the weight of radium present per gram of uranium was a constant of considerable practical and theoretical importance. The method adopted depended on the preparation of a standard solution of radium bromide and the amount of radium emanation formed in it was compared with that formed in a radio-active mineral containing a known quantity of uranium. Since the electrical comparison of the relative amounts of radium emanation can be made with considerable precision, the accuracy of the results obtained by the determination mainly depended on the exactness with which the solution of radium taken as the standard had been prepared.

The standard solution was prepared by Rutherford and Eve. A crystal of radium bromide was taken from a stock which previous experiments had shown to emit heat at the rate of 110 gram-calories per hour per gram and was consequently probably nearly pure. The amount of radium bromide was determined by direct weighing and also by comparing its γ-ray effect with that produced by a known larger weight of the same stock of radium bromide. The crystal of radium bromide was then dissolved in distilled water and by successive dilutions solutions were prepared to contain 10^{-3}, 10^{-4} and

*This Journal, xx, 55, 1905.

10^{-6} milligram of radium bromide per cubic centimeter. By evaporating known quantities of these solutions and testing the α-ray activity of the residues, Eve found that the relative activities were in close agreement with their supposed content of radium. There was, therefore, every reason to assume that the standard solutions were correct. About two months after preparation, a portion of one of these solutions was transferred to another bottle and sent to Boltwood, who, assuming the accuracy of the standard, determined by experiment that the amount of radium corresponding to one gram of uranium in a mineral was $7{\cdot}4\times10^{-7}$ gram.

Recently, however, some experiments made by Mr. Eve in the laboratory of McGill University indicated that the solution used for the above determination was in some way defective and that the quantity of radium actually in solution was less than had been assumed to be present. It was found that a considerable proportion of the radium had been deposited on the surface of the glass vessel in which the solution had been preserved and it is probable that this action had taken place before the solution sent to Boltwood was withdrawn. A full account of Mr. Eve's experiments is given by him in a paper which accompanies this in the same number of the Journal. We desire to thank Mr. Eve for his kindness in drawing our attention to this matter and for his assistance in preparing a new radium standard.

The method employed for determining the quantity of radium present in the material from which this new standard solution was prepared is described in detail in Mr. Eve's paper. The weight of radium bromide taken was ascertained by this method to be equal to 0·27 milligram. The minute fragment of salt was removed from the small sealed vial in which it had been received and was dropped into a small beaker containing a few cubic centimeters of dilute hydrochloric acid. The liquid was heated and was then carefully examined with a glass, when absolutely no trace of any insoluble material could be detected. The vial which had contained the salt was washed several times with concentrated hydrochloric acid and water, and these washings were added to the main solution. The solution was introduced into a standard graduated flask, the volume was increased to exactly 1000^{cc} by the addition of freshly distilled water, and the whole was agitated for some time in order to insure complete mixing. Ten cubic centimeters of this solution were now withdrawn with a standard pipette and introduced into a second graduated flask. A few cubic centimeters of dilute hydrochloric acid were added and the solution was diluted to 1000^{cc} with distilled water. After thorough mixing, 10^{cc} of this second

solution was removed, introduced into a bulb of about 100^{cc} capacity and diluted to about 50^{cc} with distilled water. The contents of the bulb were boiled vigorously for about ten minutes and the tubular orifice of the bulb was then sealed by fusion.

After a period of exactly four days had passed the emanation which had accumulated in the bulb was removed by continued boiling of the solution, and was transferred to an air-tight electroscope and its activity measured. The leak due to the emanation was equal to 4·27 divisions per minute, and the calculated leak corresponding to the maximum equilibrium quantity of emanation was 8·44 divisions per minute. On the basis of 0·27^{mg} of pure radium bromide originally taken, the amount of radium contained in the solution in the bulb was $1{\cdot}57 \times 10^{-9}$ milligram.

The leak corresponding to the equilibrium quantity of radium emanation formed by the radium associated with one gram of uranium in a natural mineral was next determined. The mineral chosen was a pure North Carolina uraninite containing 68·2 per cent of uranium. The leak in the same electroscope corresponded to 206 divisions per minute per gram of uranium. From the above numbers it can readily be calculated that *the quantity of radium associated with one gram of uranium in a radio-active mineral is equal to approximately* $3{\cdot}8 \times 10^{-7}$ *gram.*

The value of the new number is about one-half that of the old. On the present basis the ores of uranium per ton of 2,000 pounds will carry about 0·0034 gram of radium for every per cent of uranium present. A ton of 60 per cent uranium ore will therefore carry about 0·20 gram of radium equivalent to 0·35 gram of radium bromide. These numbers are more nearly in accord with the quantities of radium extracted from the ores in actual practice than were those derived on the basis of the former standard.

April, 1906.

Art. II.—*The Measurement of Radium in Minerals by the γ-Radiation;* by A. S. Eve.

The usual method of determining the amount of radium in a mineral is by measuring the maximum activity of the emanation obtained from a solution. Good results have been obtained in this way by Strutt, and by Boltwood. Again, the quantity of uranium present is usually found by chemical analysis; and a measure of the active matter in a sample of pitchblende can be found by observing the α-radiation from a fine powder constituting an average sample of the mineral.

In the present paper, an account will be given of another method capable of giving equally accurate results. It was due to a suggestion by Professor Rutherford that it would be interesting to ascertain if radium E emitted γ-rays. This was to be expected because he had already proved that radium E gave rise to β-rays, and in all known cases these are accompanied by γ-rays, and are probably their immediate cause. In a newly prepared sample of radium bromide, there has not been sufficient time for the growth of the slow transformation products, so that very little radium E is present. But uraninite, which emits but a small fraction of its emanation, must necessarily contain radium E almost in an equilibrium amount.

The results of some preliminary experiments have been published in a recent number of the Philosophical Magazine.* The writer proved that the γ-radiations from radium, thorium and radio-thorium were practically identical in character, being very penetrating and absorbed to an equal degree by lead. On the other hand, the γ-rays from uranium and actinium were feeble and readily absorbed. It is, therefore, possible to cut off the γ-rays arising from uranium or actinium in a substance, and yet to have a strong γ-radiation, due to radium or thorium, penetrating the screen. In this way it is easy to measure the amount of radium or of thorium present in any ore, or in a solution, and the active substance need not be powdered, or dissolved, or removed from bottle or test tube. It is only necessary to place the substance under a lead screen about one centimeter thick and to observe the fall of the gold leaf of the electroscope. Then a standard of known magnitude, consisting of radium or thorium, is similarly placed, and the fall of potential is again observed for the same period as before. The saturation-currents in the two cases are proportional to the quantities of radium or of thorium present. This method of determining the amount of radium or of thorium

* A. S. Eve, Phil. Mag., April, 1906.

present applies to ores which contain only uranium or only thorium. If the ore consists of a mixture of these two elements, the method cannot be applied except to obtain their joint amount. With these limitations, the method is capable of giving exact results, but when the amount of substance employed is large, a correction may be necessary for the absorption of the rays in the substance itself.

Specimens of uraninite from Joachimstahl were obtained, weighing a kilogram, and it was found that radium E, assuming it to be present, either does not emit γ-rays, or, more probably, it emits γ-rays which, like those of uranium, are of a feeble penetrating nature. The very penetrating radiation from pitchblende can therefore be wholly attributed to the presence of radium C.

In the course of this work the amount of radium present in the kilogram of uraninite was found to be of the order of the amount contained in a quarter of a milligram of pure radium bromide. Consequently it was possible to estimate the amount of uranium contained in the ore, using as a basis of calculation the result of Rutherford and Boltwood that 1 gram of uranium contains $7{\cdot}4\times10^{-7}$ grams of radium. The amount of uranium thus determined was surprisingly small, and in consequence part of the pitchblende was sent to Dr. Boltwood at New Haven in order to check the results in the two laboratories, and to get at the bottom of the divergence in results.

Dr. Boltwood found that the radium present was about twice as great as in the determination by the writer at Montreal. As both Dr. Boltwood and myself were confident of the accuracy of our measurements, and as both methods appeared to be above suspicion, an examination was made of the standards on which the measurements depended.

It is, therefore, necessary to give some account of the standard solutions employed by Dr. Boltwood. In March, 1905, a crystal of radium bromide was taken from a supply which Professor Rutherford found gave a heating effect of 110 gram-calories per hour per gram, and which was presumably pure. This was compared by Professor Rutherford, using the γ-ray test, with a larger known quantity of radium bromide, and it was also weighed carefully by the writer. The results were in excellent agreement, and the weight determined was $\cdot95^{mg}$. The crystal was placed in 95^{cc} of distilled water, and fractions of the solution were then drawn off, and water was again added so that three glass flasks were filled, containing 10^{-3}, 10^{-4}, 10^{-5} mg of radium bromide per c.c. of water. Portions of these were evaporated to dryness in small zinc trays, the resulting activities were measured and their ratios were found to be satisfactory. The standards were sealed and put aside

for permanent use. Unfortunately, no acid was added to the solution, and, in the light of subsequent events, this omission was serious, although the step did not appear necessary at the time. Some time later, Professor Rutherford supplied part of the medium (10^{-4} mg per c.c.) solution to Dr. Boltwood, and on this standard their joint results depended. The advantage of using this standard was obvious, as it would presumably place in agreement the results obtained at Montreal and New Haven.

In January, 1906, when the discrepancy before mentioned, concerning the amount of radium in uraninite, was discovered, the writer examined the standard solutions which had been prepared ten months previously. On drawing off one-half of the strongest solution, placing it in a clean bottle, sealing it, and testing it when in equilibrium, it was found that the activity in the new bottle was only about one-half that remaining in the old. It was proved beyond doubt that the total amount of radium in the bottle was correct, but that the radium was not all in solution, the water containing only fifty per cent of the total radium present.

As soon as it was ascertained that the standards were no longer correct, Dr. Levin and the writer weighed, with different weights and balances, 3·69mg of radium bromide, from the supply which Professor Rutherford found gave a heating effect of 110 gram-calories per gram per hour. The results of the two weighings were in excellent agreement, and the crystals were then sealed in a test tube in the solid state to serve as a standard for future use. A smaller crystal was also sealed in a phial and compared with the new standard by the γ-ray test. The activity rose slightly during the ensuing month, and was finally found to be that due to ·27mg of radium bromide. This was verified with various electroscopes, and under diverse conditions as regards screens and distances. It was now possible to redetermine the amount of radium in the kilogram of pitchblende, and the correct value was equivalent to ·32mg of radium bromide per kilogram of uraninite.

On receipt of the small crystal Dr. Boltwood found that his original solution was one hundred per cent too weak, and on redetermining the amount of radium present in the pitchblende his result, using the emanation method, was ·31mg of radium bromide per kilogram of the sample of uraninite tested. The results obtained by these two distinct methods are thus in close agreement.

From first to last, the methods used and the measurements made by all concerned appear to be correct, but errors arose because the radium bromide in the original solutions was in some way deposited on the sides and bottom of the vessels

containing the solutions. This precipitation would probably have been avoided if some hydrochloric acid had been added in the first instance.

The preparation of standards is a difficult matter. Radium is costly; small quantities only are available; it is difficult to insure purity, while the weighing of small quantities is troublesome. It appears desirable to keep two radium standards, one in the state of solution and the other in the solid state. The two standards can be compared together by their γ-ray effects from time to time.

Summary.

1. Radium E, which Rutherford proved to give β-rays, appears to give no γ-rays. More probably the γ-rays are present, but like those of uranium they are weak and readily absorbed. The very penetrating radiation from Joachimsthal uraninite can be entirely attributed to radium C.

2. Standard solutions of radium bromide, unless some acid such as HCl is present, attack or adhere to the glass of the vessel in which they are contained, and become unreliable.

3. It appears desirable to control the standard solutions by a standard of solid radium bromide sealed in a test tube.

4. Measurements of the radium present either in an ore, in a solution or in any other form, whether made by the emanation method or by the γ-ray test, are capable of giving concordant results.

5. A correction is necessary to the determination by Rutherford and Boltwood of the ratio of the weight of radium to that of uranium in radio-active minerals. The error in their determination resulted from the radium standard altering in an unexpected manner.

McGill University, Montreal, April, 1906.

Art. III.—*On the Absorption of the a-Rays from Polonium;* by M. Levin.

[Communicated by Professor E. Rutherford, F.R.S.]

In their well known investigations on the absorption of *a*-particles emitted by radium, Bragg* and Bragg and Kleeman† have shown that the *a*-particles move in a rectilinear course, spending their energy in ionization, until their velocity becomes so small that they cease ionizing. They have further shown, that the *a*-rays possess the power of ionizing a gas only within a limited distance from the source and that this distance is very sharply defined. The investigation of the *a*-ray products of radium has shown that each of the four *a*-ray products emits *a*-rays of the same range in air and the same initial velocity, and that these ranges and velocities are different for the different products. This was confirmed by experiments of Rutherford,‡ who has shown that the photographic and phosphorescent action of the *a*-rays from radium C ends abruptly at a definite distance, and that the range found by these methods agrees closely with the value determined by Bragg and Kleeman by the electric method. The hypothesis of Bragg and Kleeman that the *a*-particles from each product are initially projected at exactly the same velocity, and that this velocity is cut down by a definite amount by passing through different thicknesses of matter, has been completely confirmed by direct experiment by Rutherford.

Since the *a*-particles emitted by a thick layer of radio-active matter of one kind come from different depths, the particles which escape into the air move at different velocities. For this reason it is advisable to work with very thin films of radio-active matter. As the active deposits from radio-active emanations are deposited on bodies in infinitely thin layers, they represent ideal sources of rays for this kind of experiment. Thus the range of radium C was measured by McClung§ by using as a source of *a*-rays a wire which had been exposed to the radium emanation, and in the same way Hahn‖ has recently found the ranges of thorium B and thorium C. Bragg pointed out in his first paper that polonium, for the same reason, should be a very convenient source of *a*-rays, as it can be obtained in a very thin layer on a bismuth plate.

The object of the present experiments was to determine accurately the range in air of the ionization of the particles from polonium. As the *a*-rays emitted by each *a*-ray product have each a definite and distinct range in air, the range of the

* Phil. Mag., Dec. 1904.
† Phil. Mag., Dec. 1904, Sept. 1905, Nov. 1905, Apr. 1906.
‡ Phil. Mag., July 1905. § Phil. Mag., Jan. 1906. ‖ Phil. Mag., 1906.

a-particles, like the period of transformation, is a characteristic constant of each product, and the accurate knowledge of these ranges seems to be of importance at the present state of our knowledge of radio-active transformations. It was also of interest to examine the ionization due to the *a*-rays of polonium at different distances from the source in order to see if it emitted only one type of *a*-rays. A similar examination of the active deposit of thorium by Hahn* had disclosed the unexpected fact that two different *a*-ray products were present instead of one, as was previously supposed.

For the experiments a bismuth rod, coated with a thin film of polonium (radio-tellurium), obtained from Sthamer of Hamburg, was used.

Measurements by the Scintillation Method.

First the range in air of the *a*-particles was measured by the scintillation method in the usual way. The active rod was placed beneath a zinc-sulphide screen, and the distance at which the scintillations just disappeared was measured. Several layers of aluminium foil, each of about the thickness of ·0003^{cm}, were placed above the rod and the range again measured. The results of one series of experiments are given in Table I.

TABLE I.

Number of aluminium foils.	Distance between rod and screen in centimeters.	Centimeters of air corresponding to one layer of foil.
0	3·78	
1	3·29	·47
2	2·78	·50
3	2·30	·49
4	1·84	·48
5	1·35	·49
6	·82	·40
7	·32	·50
		Mean ·49

Thus the range of the *a*-particles in air is 3·78^{cm}. By plotting the numbers of layers as abscissæ and the ranges as ordinates, one obtains approximately a straight line. This line meets the axis of ordinates a little higher than the value obtained by experiment, if no aluminium foil is used, the value found in this way being 3·82. In another series of experiments, using other samples of aluminium foil, each corresponding in stopping power to about ·53^{cm} of air, the values found for the range in air were 3·76 and 3·79^{cms}. Adams has given an account of similar measurements with several gases before the

* L. c.

meeting of the American Physical Society in December, 1905. A short abstract of his results appeared in the Physical Review, but no numbers were given.

Measurements by the Electrical Method.

The apparatus used* for these experiments was quite similar to that used by Bragg and Kleeman. A metal box contained the ionization chamber and the polonium rod. The chamber consisted of two insulated plates about ·50^{cm} apart, the upper plate being connected with the electrometer and the lower

1

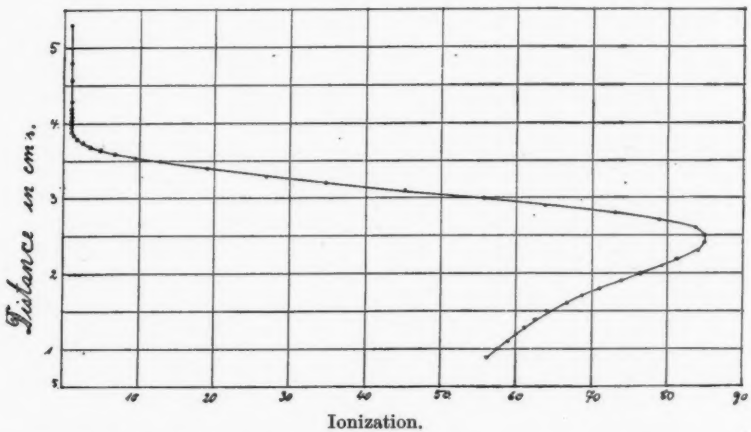


plate of wire gauze with the battery. The polonium rod was placed in a little groove made in a lead block and was covered with a lead plate about ·6^{cm} thick having a circular hole of ·4^{cm} diameter passing vertically through it. The lead block was placed inside the vessel on an upright support, which could be moved vertically. The cone of rays issuing from the opening in the lead plate was sufficiently narrow so that its cross-section never covered the whole surface of the ionization chamber. The saturation-current produced in the ionization chamber was measured for different distances between the polonium rod and the wire gauze.

The ionization of the rays in air at different distances from the source was first investigated. The results are shown in figure 1, where the ordinates represent the distance from the upper surface of the rod to the gauze in centimeters, the abscissæ the ionization measured in arbitrary units.

* I am indebted to Dr. Hahn for his kindness in allowing me to use the experimental arrangement which he had previously employed in his determinations of the range of the α-rays from the products of thorium and actinium.

The shape of the curve is very similar to that obtained by Bragg and Kleeman for the *a*-rays from a thin film of radium and by McClung for a thin film of radium C. The ionizing power of the *a*-particle steadily increases with the distance, passes through a well-marked maximum and then rapidly falls off. In the experiments the ionization chamber had a depth of 5^{mm} as stated above, and the cone of rays was not very narrow. The ionization per centimeter of path consequently appears to fall off more slowly than would be observed with a shallower ionization chamber and a very narrow cone of rays.

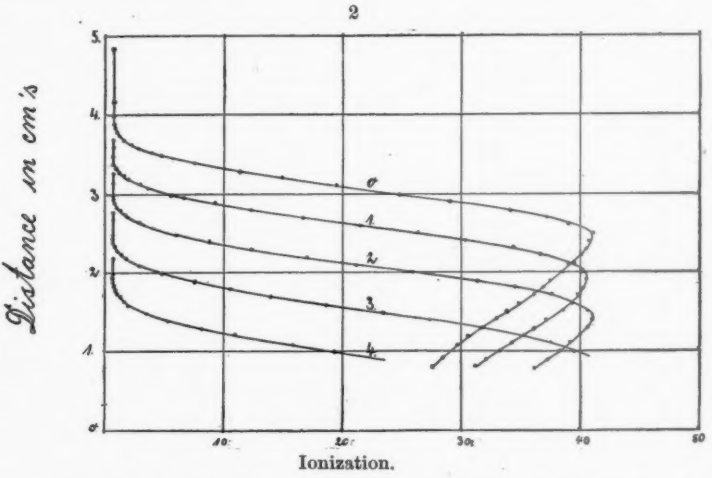


Figure 2 shows the curves obtained when the rod was covered with different layers of aluminium foil, the numbers of the curves giving in each case the number of layers of aluminium foil employed.

It is seen from the curves that the interposition of a sheet of aluminium foil does not at all alter the general shape of the curve, but that the effect of the screen is to lower the ionization curve by a definite distance corresponding to the equivalent in air of the stopping power of the aluminium screen. The amount of the maximum ionization is not affected by the absorption of the *a*-rays in the aluminium foil, thus agreeing with the view of Bragg, that the *a*-rays are not absorbed according to an exponential law, but that the whole number of *a*-particles passes the aluminium sheet, their velocity all being diminished by a definite amount.

In Tables II and III, the distances between the rod and the lower plate of the ionization chamber are given, for which the *a*-particle begins ionizing.

TABLE II.

Number of aluminium foils.	Distance in centimeters.	Distance in air corresponding to one aluminium foil.
0	3·87	
1	3·37	·50
2	2·84	·51
3	2·33	·51
4	1·83	·51
		Mean ·51

TABLE III.

Number of aluminium foils.	Distance in centimeters.	Distance in air corresponding to one aluminium foil.
0	3·85	
1	3·36	·49
2	2·86	·48
3	2·35	·50
4	1·82	·50
		Mean ·49

The break in each of the curves is very sharply marked, so that the point where the ionization begins could be obtained from the curves with an error of about ·2^{mm}. There is, however, a little uncertainty about the actual values, because the gauze could not be obtained quite plane. The mean of these experiments gives the range of the *a*-particles of polonium to be 3·86^{cm}. The average, from the scintillation measurements, is 3·77, and from the extrapolated values 3·81.

Wigger* found that the ionization due to the *a*-rays of polonium extended in air to a distance of about 4^{cm}. He used, however, a large plane surface of polonium as a source of rays and did not obtain the ionization-distance curve, for which, as we have seen, a definite narrow cone of rays must be employed.

Using the *a*-rays of radium as a source, Bragg has shown, that the stopping power of the *a*-particle, passing through an atom, is proportional to the square root of the atomic weight. Adams (loc. cit.) states that he has verified the law with the *a*-rays of polonium, using the scintillation method. As the scintillation and electrical method give probably identical results, there was no object to be gained in determining by the electrical method the range of the *a*-rays of polonium in other gases besides air.

The results of this investigation have shown, that polonium is a homogeneous source of *a*-rays, and that the *a*-particles are initially projected with the same velocity. The range in air of the *a*-particles is 3·86^{cm}, which is slightly greater than the range of the *a*-particles (3·50^{cm}) of radium itself, but much less than that for the *a*-particles from radium C (range 7·06^{cm}).

I wish to express my best thanks to Professor Rutherford for the kind interest he took in this work, and for the advice received from him.

McDonald Physics Building, McGill University,
Montreal, 20 May, 1906.

* Jahrbuch der Radio-aktivität, ii, 391, 1906.

ART. IV.—*The Thermal Constants of Acetylene;* by W. G. MIXTER.

[Contributions from the Sheffield Chemical Laboratory of Yale University.]

SOME years ago the writer observed* that the thermal constants of acetylene found by different observers varied widely, and that his result for the heat of dissociation of the gas was considerably higher than the calculated value. It was evident that a complete investigation of the matter involved a study of the components of acetylene. Accordingly the heat of combustion of hydrogen was determined.† The results of Thomsen, Schuller and Wartha, Than, and the writer gave a value with probably a small error. The heat found on burning acetylene carbon‡ was about two per cent higher than that of the ordinary forms of amorphous carbon. The thermal constant of this allotrope of carbon is essential in calculating the heat of dissociation of acetylene.

For the thermal work on carbon acetylene carbon was prepared with care, and at the same time new determinations of the heat of dissociation of acetylene were made. The bomb used was similar to the one described in the paper on carbon but with electrodes in the upper end of the stem. Both bombs were alike in external volume and surface. One bomb was filled with pure hydrogen and exhausted and counterpoised by the other bomb and the needed weights. Then it was filled with dry acetylene from carbide and at a pressure of ten or twelve atmospheres. Next 100^{cc} of the gas in the bomb were passed into a eudiometer and the acetylene determined by means of ammoniacal cuprous chloride. It varied in the different experiments from 98·6 to 99 per cent. Finally the weight was noted. The water equivalent of the calorimeter was found as described in the paper on carbon.

Experiment 1.—Acetylene, 6·3162 grams; water, 3160·0 grams; water equivalent of calorimeter, 285·2 grams; water equivalent of hydrogen and carbon formed, 2·1 grams. Total, 3447·3 grams.

Minutes.	Temperature.	Temperature interval.
0	18·204	
1	18·207	
2	18·210	21·995 − 18·21 + 0·01 = 3·775°
3	21·8	
4	21·9	Heat observed, 3447·3 × 3·775 = 13014^c
5	31·97	
6	21·977	For 1 gram of acetylene 2060^c
7	21·975	
8	21·973	
9	21·970	
10	21·966	
11	21·962	

* This Journal, xii, 347, 1901. † Ibid., xvi, 214. ‡ Ibid., xix, 434.

Experiment 2.—Acetylene, 6·4419 grams; water and water equivalent, 3482·2 grams.

Minutes.	Temperature.	Temperature interval.
0	18·201	
1	18·203	
2	18·206	22·039 − 18·209 + 0·011 = 3·841°
3	18·209	
4	21·6	Heat observed, 3482·2 × 3·841 = 13375°
5	22·0	
6	22·044	For 1 gram of acetylene 2076°
7	22·042	
8	22·039	
9	22·036	
10	22·034	
11	22·031	
12	22·028	

Experiment 3.—Acetylene, 6·1254 grams; water and water equivalent, 3484·9 grams.

Minutes.	Temperature.	Temperature interval.
0	18·333	
1	18·337	
2	18·340	21·982 − 18·34 + 0·008 = 3·65°
3	21·8	
4	21·9	Heat observed, 3484·9 × 3·65 = 12720°
5	21·984	
6	21·984	For 1 gram of acetylene 2077°
7	21·982	
8	21·980	
9	21·978	
10	21·976	
11	21·974	

The mean temperature in these experiments was 20·12°. The average of the results, 2060, 2076 and 2077, is 2071 for the heat of dissociation of one gram of acetylene at 20° and in terms of the water calorie at this temperature. For the gram molecule, 26·016, it is 53879. This figure is one per cent higher than that found in the earlier experiments and carries a greater weight on account of somewhat improved apparatus.

Heat of Combustion of Acetylene.

The acetylene used was made from carbide and collected over water containing ferrous hydroxide to absorb oxygen. The bomb was filled and the percentage of acetylene in the gas determined as already described, and the usual precautions were taken for finding the volume, temperature, and pressure of the gas. The density of acetylene adopted, 0·0011687, was derived from the molecular weight, 26·016, and the density of

hydrogen at the latitude of New Haven. The oxygen used was free from water, hydrogen, and carbon compounds, containing, however, about one per cent of nitrogen. After each of the calorimetric tests the silver dissolved as nitrate was precipitated as chloride. The amount, however, was so slight that no correction was made for the oxidation of nitrogen.

To Professor H. A. Bumstead the writer is indebted for the following method of reducing the results.

The general formula for reducing the heat of combination, found under the condition of constant volume, and between the temperatures t_1 and t, to that found at 0° and under constant pressure, is easily obtained by imagining the mixed gases to be carried through two different processes from the same initial state to the same final state, and equating the losses of energy in the two processes.

First Process.—M grams of mixed gases at $p_1 V_1 t_1°$ are cooled and compressed or expanded to $p_0 V_0 0°$. By Joule's law energy given out is $MC_v t_1$ where C_v is the sp. ht. (const.-vol.) *of the mixed gases.* It is then burned at constant pressure, p_0, giving out Q calories, its volume simultaneously diminishes by $\frac{3}{7} V_0$, and work is done upon it equal to $\frac{3}{7}\frac{p_0 V_0}{J}$ calories.

$$\therefore \text{Loss of energy} = Q + MC_v t_1 - \frac{3}{7}\frac{p_0 V_0}{J}$$

$$\text{Final state is } (p_0, \tfrac{4}{7} V_0, 0).$$

Second Process.—M grams are burned at const. vol. V_1, temperature rising from t_1 to t giving out Q′ calories; we have now to reduce the mixture of CO_2, water and water vapor, to $p_0, \frac{4}{7} V_0, 0°$ to bring it to the same final state as by the previous process. No matter what the details of the process, the energy given out by the CO_2 in this operation will be (Joule's law). $mc_v t$; where m and c_v are the mass and specific heat of CO_2. We may therefore consider the water vapor separately. Suppose it first compressed at constant temperature t until it is wholly condensed; the work done on the vapor will be

$$\frac{\pi_t V_1}{J} \text{ calories}$$

when π_t is the pressure of water vapor at $t°$. The latent heat given out will be $\sigma_t L_t V_1$ where σ_t and L_t are the density and latent heat per unit mass at t. Let the water now be cooled to 0 degrees; the heat given out is $m_w t$, where m_w is the mass of the water formed.

Total energy given out is

$$Q' + mc_v t + V_1\left(\sigma_t L_t - \frac{\pi_t}{J}\right) + m_w t.$$

Hence

$$Q + MC_v t_1 - \frac{3}{7}\frac{p_0 V_0}{J} = Q' + mc_v t + V_1\left(\sigma_t L_t - \frac{\pi_t}{J}\right)$$

$$Q = Q' - MC_v t_1 + \frac{3}{7}\frac{p_0 V_0}{J} + mc_v t + V_1\left(\sigma_t L_t - \frac{\pi_t}{J}\right) + m_w t.$$

For reducing from 0° to 18° at constant pressure we have

$$Q'' = Q + MC_p t - mc_p t - mwt.$$
$$Q'' = Q - 178.$$

The specific heats of the gases used in the calculations were the following: Acetylene, 0·3 p. c., 0·2 v. c.; carbon dioxide, 0·2 p. c., 0·15 v. c.; oxygen, 0·21 p. c., 0·15 v. c. The specific heat of acetylene has not been determined, and it is assumed to be the same as that of benzol vapor.

Experiment 4.—Gas, 569·3^{cc} at 20·6° and 756·2^{mm} pressure; gas, 98·95 per cent acetylene; weight of acetylene, 0·6091 gram; water and water equivalent of calorimeter, 3249·3 grams; oxygen, 3·3 grams.

Minutes.	Temperature.	Temperature interval.
0	18·304	
1	18·308	$20·552 - 18·312 = 2·24°$
2	18·312	
3	20·5	Observed heat, $3249·3 \times 2·24 = 7278·5^c$
4	20·54	
5	20·547	
6	20·550	
7	20·552	
8	20·552	
9	20·551	
10	20·553	
11	20·553	

$$Q' = \frac{7278·5 \times 26·016}{0·6091} = 310880$$

$$MC_v t = -315$$

$$\frac{3}{7}\frac{p_0 V_0}{J} = 810$$

$$mc_v t = 271$$

$$V_t\left(\sigma_t L_t - \frac{\pi t}{J}\right) = 253$$

$$m_w t = 370$$

$$Q = 312269^c$$

Experiment 5.—Gas, 569·3^{cc} at 20·9° and 760·8^{mm} pressure; gas, 98·1 per cent acetylene; weight of acetylene, 0·6069 gram; water and water equivalent of calorimeter, 3113·1 grams; oxygen, 3·1 grams.

Minutes.	Temperature.	Temperature interval.
0	20·372	
1	20·373	
2	22·5	22·701 − 20·273 + 0·006 = 2·334°
3	22·6	
4	22·701	Observed heat, 3113·1 × 2·334 = 7266^{c}
5	22·701	
6	22·701	From these data we have for the
7	22·699	value of Q = 312895^{c}.
8	22·698	
9	22·696	
10	22·695	

Experiment 6.—Gas, 569·6^{cc} at 20·5° and 757·8^{mm} pressure; gas, 98·5 per cent acetylene; weight of acetylene, 0·6084 gram; water and water equivalent of calorimeter, 3231·3 grams; oxygen, 3·4 grams.

Minutes.	Temperature.	Temperature interval.
0	19·348	
1	19·349	
2	19·350	21·597 − 19·35 + 0·01 = 2·257°
3	21·5	
4	21·57	Observed heat, 3231·3 × 2·257 = 7293^{c}
5	21·599	
6	21·599	
7	21·597	Q = 313401^{c}
8	21·593	
9	21·591	
10	21·588	
11	21·587	
12	21·585	
13	21·583	

The results are as follows:

No. of Exp.	Calories
4	312269
5	312895
6	313401
Average	312855

This is for the heat of combustion of 26·016 grams of acetylene at constant pressure at 0°, and at 18° it is 312677. The results of the earlier work reduced by Professor Bumstead's

equation gave an average of 312990. Little significance is, however, attached to the latter figure as the experiments from which it is derived showed differences as great as 1·6 per cent.

Comparing the heat of combustion of acetylene with that of its components plus the heat of dissociation we have:

				Calories
Heat of combustion of	2·016	grams of	hydrogen,	68440
" "	24	"	acetylene carbon,	189456
" dissociation	26·016	"	acetylene,	53879
				311775
Heat of combustion of	26·016	grams of	acetylene,	312677
Difference,				902

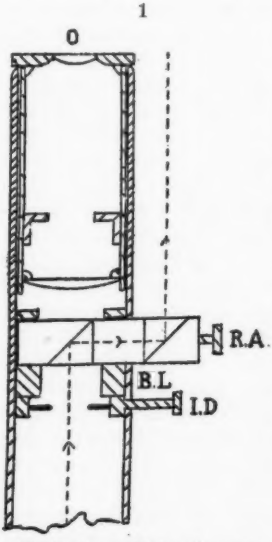
Since the explosions of acetylene under pressure and of mixtures of this gas and oxygen are among the most violent chemical changes known, producing a temperature of 2700° or higher, the question arises, Is there any atomic disintegration by which radio-active gases are produced? The calorimetric results do not indicate that any thermal effect is due to such change. The products of explosions were therefore tested in an electroscope similar to the one described by Professor Boltwood.* The fall of the gold leaf was observed with a microscope. The experiments were as follows: Acetylene gas collected over unboiled tap water caused a slightly greater leak than air, as might be expected, since the waters of this locality contain a radio-gas†. Accordingly gas from carbide was collected over water which had been boiled an hour or two. Acetylene containing a trace of phosphoretted hydrogen caused no greater leak than air. The hydrogen resulting from an explosion of such gas under pressure contained a phosphorus compound and gave rather more leak than air. When, however, the acetylene was free from phosphoretted hydrogen the hydrogen it yielded gave the normal leak. Repeated tests made with the gas remaining after the explosion of a mixture of acetylene and oxygen gave negative results. Freshly prepared acetylene carbon produced in two experiments more than the normal leak but the effect was slight. This may have been due to ionization of the air caused by chemical change such as the oxidation of the hydrocyanic acid adhering to the carbon.

In conclusion it may be stated that no indication was found of atomic disintegration or energy resulting except from ordinary change.

* This Journal, xviii, 97. † Bumstead, Ibid., xvii, 97.

ART. V.—*A Modification of the Lasaulx Method for Observing Interference Figures under the Microscope;* by FRED EUGENE WRIGHT.

OF the many plans which have been proposed for adapting the microscope to observations in convergent polarized light the method of Lasaulx is probably the best and is in general use by petrologists at the present time. His mode of procedure consists in observing the image of the interference figure directly, as it is brought to focus by the high power objective alone, without the aid of ocular and compensating lens. The interference figures thus produced, when compared with those obtained by other methods, are smaller but more distinct and brighter and therefore better suited to general work. The weak point of the method is the time lost in removing and replacing the ocular for each observation and the annoyance caused thereby.



Vertical section of upper part of microscope tube showing position of reflecting when inserted. O, ocular; R. A., reflecting apparatus; B. L., position for Bert and lens; I. D., iris diaphragm.

The following device has been constructed to obviate this difficulty by reflecting the light rays to one side of the ocular, as shown in the diagram (fig. 1), and has been found in practice to answer the purpose well. In the writer's microscope the small reflecting apparatus fits in a narrow slot in the microscope tube between the base of the ocular in position and the iris diaphragm and, like the upper nicol prism, can be inserted or drawn out at will. The mechanical construction of the device is so simple that a good mechanic can make it without trouble. It has been observed that the loss of light on reflection is not sufficient to decrease the brilliancy of the interference phenomena appreciably.

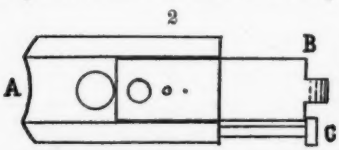
With this appliance attached to the microscope the passage from plane parallel to convergent polarized light is easily effected by inserting the reflecting apparatus and observing then the interference phenomena at one side of the ocular. The ocular remains thereby in place and practically no time is wasted during the operation.

Sliding Stop Diaphragms as Substitutes for the Iris Diaphragms in Petrographic Microscopes.

In microscopic work it has been found by petrologists that many optical phenomena are rendered more apparent by the

use of diaphragms both below and above the condenser and objective lens systems of the microscope; that, by closing gradually the lower iris diaphragm not only is the definition improved but also methods based on the relative refractive indices of adjacent mineral sections, as the Becke line method, are materially bettered; and that, by closing the upper diaphragm in like manner, interference figures in convergent polarized light can be observed from minute mineral plates which would be otherwise totally obscured by surrounding minerals. Ordinary petrographic microscopes, however, are not fitted with such iris diaphragms and the observations suffer accordingly.

The following sliding-stop diaphragms have been used as substitutes for the iris diaphragms and are of such nature that anyone with mechanical ability can construct similar ones for any given instrument. The upper stop diaphragm (fig. 2) is made of brass similar in general outline to that of the Bertrand lens,—the observations in convergent polarized light being made after the Lasaulx method, either by removing the ocular or by use of the reflecting apparatus described above. The stop diaphragm consists of two parts; A, the body, which is so constructed that, when inserted, the drilled hole occupies the center of the field and provides thereby one stop; and B, a thin strip of brass which fits in wedge-shaped grooves milled in A and into which the remaining stops are drilled. A short screw C provides a simple handle by which to grasp the apparatus. In actual practice the mineral section to be tested should first be sharply focussed and centered, the stop diaphragm then inserted and by means of an appropriate aperture the light from all other minerals in the section shut off, after which the observations in convergent polarized light can be made.



Sliding-stop diaphragm—a substitute for the upper iris diaphragm of a petrographic microscope.

The lower stop diaphragm is of still simpler construction and consists of a strip of brass with variable sized stops not unlike those of the above apparatus. The strip is fitted into, and guided by two wedge-shaped pieces of brass screwed to the lower end of the cylinder containing the lower nicol. The lower stop diaphragm has been found particularly useful in the application of the refractive liquid method to mineral fragments.*

Geophysical Laboratory,
Carnegie Institute, Washington, D. C.

* Compare Tschermak's Miner. petr. Mitteil., 1901, xx, pp. 239 and 251. Strips of thin cardboard with appropriate perforations can be used as temporary substitutes for both iris and sliding stop diaphragms.

Art. VI.—*Datolite from Westfield, Massachusetts;* by E. H. Kraus and C. W. Cook.

Several months since, the Mineralogical Laboratory of the University of Michigan purchased from Ward's Natural Science Establishment of Rochester, N. Y., an excellent suite of datolite crystals from Westfield, Mass. At that time, crystals of datolite from this locality had not been described, and it was therefore decided to carry out a chemical and crystallographical investigation of the same. Recently, however, Whitlock* described several datolites from this locality. Whitlock confined himself to a crystallographic study of these interesting crystals, and since our investigations not only corroborate many of his observations, but also give some additional facts, we have thought it wise to present the same in detail.

Crystallography.—The original purchase consisted of sixteen crystals varying from an half to an inch and an half in diameter. Subsequently fifteen others were added, so that thirty-one crystals from this locality are now in the possession of this laboratory. However, through the kindness of Ward's Natural Science Establishment, all of the material in their possession was placed at our disposal, so that in all, forty-seven crystals were examined.

According to Mr. R. F. Jones, by whom the crystals were collected, the datolite occurs in the cracks and crevices of Lane's Trap Quarry, Westfield, Mass., half way between Springfield and Westfield.† Most of the specimens seem to have been collected during the past two years. All the crystals are exceedingly clear and transparent and of such sizes as to make accurate goniometric observations possible. Four distinct types of development were noted.

Even though datolite has from time to time been studied crystallographically, there is still considerable difference of opinion as to the selection of the a and c axes. Although Hess‡ and Schroeder§ had previously shown that datolite crystallizes in the monoclinic system instead of orthorhombic as assumed by Lévy,‖ Haüy,¶ and Miller,** it remained for Dauber†† to positively establish the fact. The elements of crystallization obtained by Dauber are:

$$a : b : c = 1{\cdot}26574 : 1 : 0{\cdot}63446 \quad \beta = 90^\circ\ 9'.$$

In so doing the form m_x (fig. 1) was assumed as the unit

*N. Y. State Museum, Bull. 98, 19.
†Compare Whitlock, N. Y. State Museum, Bull. 98, 19.
‡Pogg. Annalen, xciii, 380, 1854.
§Ibid., xciv, 235, 1855; also xcviii, 34, 1856.
‖Description d'une collection de mineraux, etc., pp. 179 and 182, 1838.
¶Dana, System of Mineralogy, 6th ed., 1892, 505.
**Mineralogy, 1852, 408.
††Pogg. Annalen, ciii, 116, 1858.

prism. Rammelsberg,* in establishing the isomorphism between datolite, gadolinite, and euclase, accepted the position proposed by Dauber but made *g* (fig. 1) the unit prism, whereby the ratio was reduced to

$$0{\cdot}6329 : 1 : 0{\cdot}6345.$$

Groth,† Liweh,‡ Goldschmidt,§ and others have accepted these values. Hintze‖ accepts the statement of Lüdecke¶ that this position is the more natural and gives the simpler indices. Lüdecke's argument, moreover, loses its force when we con-

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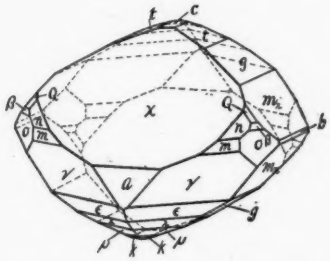


sider that seventeen of the thirty new forms described by him were afterwards shown by Goldschmidt** to belong to anglesite and not to datolite. Dana,†† however, does not accept the above position, but follows Lévy‡‡ and interchanges the *a* and *c* axes. In so doing the values obtained by Dauber are taken, so that the ratio adopted by Dana is:

$$a : b : c = 0{\cdot}63446 : 1 : 1{\cdot}26574.$$

We agree with Dana that this position permits of a more natural interpretation of the crystals and also affords the simpler indices. This position is, therefore, the one accepted by us. As indicated by Dana,§§ the isomorphism existing between datolite, gadolinite, and euclase can be shown by this position just as well as by the one adopted by Rammelsberg.

The four types of development already referred to may be described briefly as follows:

Type one (fig. 1), as noted by Whitlock, is the predominating habit. Thirty-four crystals were found to possess this

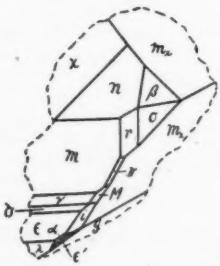
* Zeitschr. der Deutsch. Geol. Ges. xxi, 807.
† Tabellarische Uebersicht der Mineralien, 1898, 116.
‡ Zeitschr. für Krystallographie u. s. w., vii, 569, 1883.
§ Index der Krystallformen der Mineralien, 1886, I, 485.
‖ Handbuch der Mineralogie, II, 164.
¶ Zeitschr. für Naturwissenschaft, lxi, 235–404, 1888.
** Zeitchr. für Krystallographie, xviii, 280, 1890.
†† System of Mineralogy, 6th edition, 1892, 504 and 505.
‡‡ Loc. cit. §§ Loc. cit.

development, which may be characterized as the pyramidal habit. The following forms were observed on this type:

$a\{100\}$, $b\{010\}$, $c\{001\}$, $m\{110\}$, $r\{230\}$, $o\{120\}$, $l\{130\}$, $x\{102\}$, $v\{103\}$, $u\{104\}$, $m_x\{011\}$, $g\{012\}$, $t\{013\}$, $m_y\{067\}$ (new), $m_z\{0{\cdot}1{\cdot}10\}$ (new), $n\{111\}$, $\beta\{121\}$, Q$\{122\}$, $\nu\{\bar{1}11\}$, $\mathfrak{d}\{\bar{2}23\}$, $\epsilon\{\bar{1}12\}$, $\lambda\{\bar{1}13\}$, $\mu\{\bar{1}14\}$, $\kappa\{\bar{1}15\}$, $n_z\{\bar{1}{\cdot}1{\cdot}10\}$ (new), M$\{\bar{1}22\}$, $i\{\bar{1}23\}$, $a\{\bar{1}24\}$, $\pi\{\bar{2}31\}$, $\acute{\epsilon}\{\bar{1}48\}$, $\mu'\{1{\cdot}4{\cdot}10\}$.

The pinacoid $a\{010\}$ is always present as a brilliant face. The form $b\{010\}$ occurs on about fifty per cent of the crystals of this type. When present, it appears as a narrow edge giving good reflections. $c\{001\}$ is generally very small, often giving no image whatever. The prism $m\{110\}$ is usually to be observed as a thin edge and is always present. $o\{120\}$, which is frequently present, possesses two characteristic outlines (figs. 1 and 4). In some instances it shows natural etching. It then appears as a very dull face giving poor reflections. $r\{230\}$ (fig. 2) was noted on several crystals, giving very good readings. $l\{\bar{1}30\}$ was observed on but one crystal, beveling the edge between the faces $\nu(11\bar{1})$ and $m_x(011)$.

2



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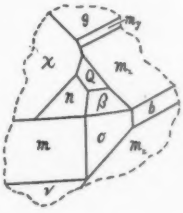

The negative hemi-orthodome $x\{102\}$ is the predominating form of this type and aids materially in orientating the crystals. The faces are often broken and the surfaces are more or less uneven, and hence give poor reflections. $v\{103\}$ and $u\{104\}$ were observed but once as very small, narrow edges. Of the clino-domes $m_x\{011\}$, $g\{012\}$, and $t\{113\}$ are always present. Of these forms, $m_x\{011\}$ is always large. $m_y\{067\}$ (fig. 3) and $m_z\{0{\cdot}1{\cdot}10\}$ are new to datolite. Even though they were observed on only two crystals, the observed and calculated angles, nevertheless, leave no doubt as to their identity.

	Observed.	Calculated.
$m_y : m_y = (067) : (0\bar{6}7)$	94° 39′	94° 46′
$m_z : m_z = (0{\cdot}1{\cdot}10) : (0{\cdot}\bar{1}{\cdot}10)$	14 38	14 25

Of the pyramids, $n\{111\}$, $\beta\{121\}$, $\nu\{\bar{1}11\}$, $\epsilon\{112\}$, $\lambda\{\bar{1}13\}$, $\mu\{114\}$ are generally present,—$\nu\{\bar{1}11\}$ usually predominating.

Q{122} is frequently present,—often as a dull face giving no reflection.

$\mathfrak{d}\{\bar{2}23\}$, sometimes quite large, is among the commonly observed forms.

M{$\bar{1}$22}, $i\{\bar{1}23\}$, and $a\{\bar{1}24\}$ are also among the forms frequently observed. The new forms $\epsilon'\{\bar{1}48\}$ and $\mu'\{\bar{1}\cdot4\cdot10\}$, noted first by Whitlock, were observed on several crystals. $\mu'\{\bar{1}\cdot4\cdot10\}$ gave very good readings, but $\epsilon'\{\bar{1}48\}$ was identified by zonal relationship. The location of these forms is shown

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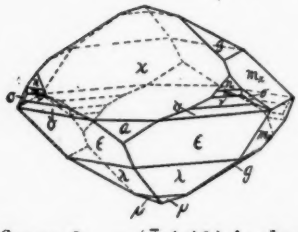

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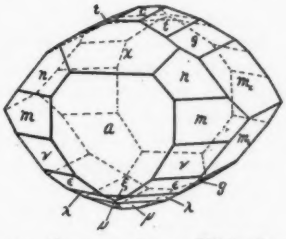

in figure 2. $n_z\{\bar{1}\cdot1\cdot10\}$ is also new to the species. This form may be considered well established, as shown by the following angles:

	Observed.	Calculated.
$m : n_z = (110) : (\bar{1}\cdot1\cdot10)$	76° 49′	76° 52′

Type two (fig. 4) also possesses a pyramidal habitus. It is distinguished from type one chiefly by the absence of the basal and clino-pinacoids. This type was observed seven times, possessing the following forms:

$a\{100\}$, $x\{102\}$, $m_x\{011\}$, $g\{012\}$, $m\{110\}$, $o\{120\}$, $n\{111\}$, $\mathfrak{d}\{223\}$, $\epsilon\{\bar{1}12\}$, $\lambda\{\bar{1}13\}$, $\mu\{\bar{1}14\}$ $\nu\{\bar{1}11\}$.

The pinacoid $a\{100\}$ occurs as a small triangular face giving excellent reflections. As in type one, the hemi-orthodome $x\{102\}$ is the predominating form. The prisms $m\{110\}$, and $o\{120\}$ are always present though generally small,—$o\{120\}$ beveling the edge between the faces $\nu(11\bar{1})$ and $m_x(011)$. Of the pyramids, $\epsilon\{\bar{1}12\}$ and $\lambda\{\bar{1}13\}$ present large, uneven faces. $\mathfrak{d}\{\bar{2}23\}$ is usually dull. The other pyramids appear as very small faces.

Type three (fig. 5) was observed on four crystals. It may be characterized as possessing a prismatic habitus. All forms are well developed,—the following being noted:

$a\{100\}$, $b\{010\}$, $c\{001\}$, $x\{102\}$, $\xi\{\bar{1}02\}$, $m_x\{011\}$, $g\{012\}$, $t\{013\}$, $m\{110\}$, $n\{111\}$, $\nu\{\bar{1}11\}$, $\epsilon\{\bar{1}12\}$, $\lambda\{\bar{1}13\}$, $\mu\{\bar{1}14\}$.

The pinacoid $a\{100\}$ is the predominating form, the others being quite equally developed. All faces except the positive

hemi-pyramid $\nu\{\bar{1}11\}$ and the positive hemi-orthodome $\xi\{\bar{1}02\}$ are brilliant, giving good reflections. $\nu\{\bar{1}11\}$ appears as a dull face in each instance. $\xi\{\bar{1}02\}$ in addition to being dull was so small that it could only be identified by zonal relationship. The three types thus far considered show a marked resemblance to the Bergen Hill* dalolites. Type three also simulates crystals from Toggiana.†

Type four (fig. 6), which was observed on two well developed crystals, possesses a tabular habitus. In some respects it resem-

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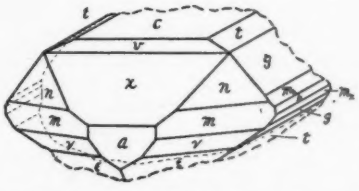

bles datolite crystals from the Lake Superior region described by Osann.‡ The following forms were noted:

$a\{100\}$, $b\{010\}$, $c\{001\}$, $m\{110\}$, $m_x\{011\}$, $g\{012\}$, $t\{013\}$, $x\{102\}$, $v\{103\}$, $n\{111\}$, $\nu\{\bar{1}11\}$, $\epsilon\{\bar{1}12\}$.

As may be seen from figure 6, the basal pinacoid $c\{001\}$ is especially prominent in this type. Of the clinodomes, $g\{012\}$ predominates,—$m_x\{011\}$ and $t\{013\}$ being comparatively narrow faces. The orthodomes $x\{102\}$ and $v\{103\}$ are both dull faces.

In all thirty-two forms were observed. They are as follows:

Pinacoids $a\{100\}$, $b\{010\}$, $c\{001\}$.
Prisms $m\{100\}$, $r\{230\}$, $o\{120\}$, $l\{130\}$.
Clinodomes $m_x\{011\}$, $g\{012\}$, $m_y\{067\}$,
$t\{013\}$, $m_z\{0\cdot1\cdot10\}$.
Orthodomes $x\{102\}$, $v\{\bar{1}03\}$, $u\{104\}$, $\xi\{\bar{1}02\}$.
Pyramids $n\{111\}$, $\beta\{121\}$, $Q\{122\}$,
$\nu\{\bar{1}11\}$, $\mathfrak{d}\{\bar{2}23\}$, $\epsilon\{\bar{1}12\}$, $\lambda\{\bar{1}13\}$,
$\mu\{\bar{1}14\}$, $\kappa\{\bar{1}15\}$, $n_z\{\bar{1}\cdot1\cdot10\}$, $M\{\bar{1}22\}$,
$i\{\bar{1}23\}$, $\alpha\{\bar{1}24\}$, $\pi\{\bar{2}31\}$, $\epsilon\{\bar{1}48\}$,
$\mu'\{\bar{1}\cdot4\cdot10\}$.

Of these $m_y\{067\}$, $m_z\{0\cdot1\cdot10\}$, and $n_z\{\bar{1}\cdot1\cdot10\}$ are new for datolite.

On account of the excellence of the various faces, the observed angles agree very closely with the calculated. The elements

* E. S. Dana, this Journal (3), iv, 416, 1872.
† Dana's System of Mineralogy.
‡ Zeitschr. für Krystallographie, xxiv, 543, 1895.

of crystallization for these crystals differ but slightly from those usually accepted, as is shown by the following:

Westfield ..... $a:b:c = 0{\cdot}63482:1:1{\cdot}26567$ $\beta = 90°\ 9'$
Dana† ..... $a:b:c = 0{\cdot}63446:1:1.26574$ $\beta = 90°\ 8\frac{2}{3}'$

The measurements give the following results:

			Observed.	Calculated.
$m : m''' = (110) : (1\bar{1}0)$	=		64° 49′*	----------
$m_x : m'_x = (011) : (0\bar{1}1)$			103 22 30″*	----------
$a : c = (100) : (001)$			89 51 *	----------
$l : l' = (130) : (\bar{1}30)$			55 19	55° 24′ 30′
$o : o = (120) : (\bar{1}20)$			76 25	76 29
$r : r''' = (230) : (2\bar{3}0)$			87 13	87 11
$m_z : m'_z = (0110) : (0\bar{1}10)$			14 38	14 25
$t : t' = (013) : (0\bar{1}3)$			45 42 30	45 45
$g : g = (012) : (0\bar{1}2)$			64 45 15	64 38 30
$m_y : m_y = (067) : (06\bar{7})$			94 39	94 46
$a : m_x = (100) : (011)$			89 56	89 54 30
$a : n = (100) : (111)$			38 57	38 56
$a : \beta = (100) : (121)$			53 44	53 44
$a : Q = (100) : (122)$			58 12	58 15 30
$a' : \nu = (\bar{1}00) : (\bar{1}11)$			39 0 30	38 59
$a' : \epsilon = (\bar{1}00) : (\bar{1}12)$			49 59	49 57
$a' : \lambda = (100) : (\bar{1}13)$			58 34 45	58 32 30
$a' : \mu = (100) : (\bar{1}14)$			64 47	64 41
$a' : k = (\bar{1}00) : (\bar{1}15)$			69 2	68 44
$a : x = (100) : (102)$			45 1	45
$a' : M = (\bar{1}00) : (\bar{1}22)$			57 24	57 49
$c : v = (001) : (103)$			33 36	33 35
$c : u = (001) : (104)$			26 35	26 29
$m : x = (100) : (102)$			53 21	53 15
$m : n = (110) : (111)$			22 57 30	22 54
$m' : \nu = (\bar{1}10) : (\bar{1}11)$			22 58 30	22 57
$m' : \mathfrak{d} = (\bar{1}10) : (\bar{2}23)$			32 28 45	32 35
$m' : \epsilon = (\bar{1}10) : (\bar{1}12)$			40 19	40 13
$m' : \lambda = (\bar{1}10) : (\bar{1}13)$			51 56	51 49
$m' : \mu = (\bar{1}10) : (\bar{1}14)$			59 20	59 15
$m' : n_z = (\bar{1}10) : (\bar{1}{\cdot}1{\cdot}10)$			76 49	76 52
$m : \beta = (\bar{1}10) : (121)$			25 41	25 38
$m : m_x = (110) : (011)$			65 9	65 7 30
$o : x = (120) : (102)$			63 59	64 3
$o : n = (120) : (111)$			29 40	29 38
$o : \beta = (120) : (121)$			17 14	17 7 30
$o' : M = (\bar{1}20) : (\bar{1}22)$			31 45	31 43
$o' : u' = (\bar{1}20) : (\bar{1}23)$			42 50	42 32
$o' : a = (\bar{1}20) : (\bar{1}24)$			51 1	51 5
$o : m_x = (120) : (011)$			51 57	51 57
$o : \pi = (\bar{1}20) : (\bar{2}31)$			13 13	13 13
$r : \pi = (\bar{2}30) : (\bar{2}31)$			10 9	10 15
$g : \mu = (012) : (\bar{1}14)$			29 16	29 13
$g : \mu' = (012) : (\bar{1}{\cdot}4{\cdot}10)$			11 17	11 19

† These values of Dauber, modified as indicated on page 22, are also accepted by Groth, Goldschmidt and others.

Natural etching is quite common, especially on the pyramids $\lambda\{\bar{1}13\}$, $\mu\{\bar{1}14\}$ and $\kappa\{\bar{1}15\}$ as noted by Whitlock.* This phenomenon is also frequently observed on the prism $o\{120\}$ and the pyramid $\beta\{121\}$. In no case, however, were the figures of sufficient size to permit an accurate determination of their outline.

Chemical Analysis. — For the chemical analysis one of the clearest crystals weighing about ten grams was selected. It was perfectly transparent and free from all inclusions. Concerning the methods which were employed, it should be stated that the boron trioxide was determined by the Gooch† method. Water was estimated as loss on ignition. The other determinations were made according to the methods recommended by Hillebrand.‡ Two analysis were made, which show very close agreement.

The results are:

	I	II	Average
SiO_2	37·60%	37·58%	37·59%
Fe_2O_3	·10	·10	·10
Al_2O_3	·14	·16	·15
CaO	34·64	34·74	34·69
MgO	·32	·31	·315
B_2O_3	21·76	21.94	21·85
H_2O	5·67	5·76	5·715
Total	100·23%	100·59%	100·41%

The average of the above analyses agrees very closely with that required for the accepted formula $HCaBSiO_5$. This was to be expected because of the unusual clearness and purity of the crystals. It is also to be noted that this analysis is very similar to Bodewig's§ of the datolite from Bergen Hill, N. J., as is shown by the following comparison:

	Theoretical	Westfield	Bergen Hill
SiO_2	37·63	37·59	37·48
Fe_2O_3	——	·10	·12
Al_2O_3	——	·15	——
CaO	34·95	34·69	35·42
MgO	——	·31	——
B_2O_3	21·81	21·85	21·14
H_2O	5·61	5·72	5·71
Total	100·00	100·41	99·87

*N. Y. State Museum, Bull. 98, 12.

†F. A. Gooch, Am. Chem. Jour., ix, 23, 1887. F. A. Gooch and L. C. Jones, this Journal, vii, 34, 1899.

‡Bulletins 148 and 176 U. S. Geol. Survey.

§C. Bodewig, Zeitschr. für Krys., viii, 211, 1884.

This similarity in the composition of the datolites from these two localities becomes more pronounced when we consider that the value given by Bodewig for boron trioxide is the mean of three determinations, one of which is 21·6 per cent. This agrees very closely with the values obtained by us.

Specific Gravity.—For the determination of the specific gravity four clear crystals of convenient size were used. The determinations were made by means of the hydrostatic balance at a room temperature of 19·5° C., the water being 21·5° C., with the following results:

I	3·0005
II	2·9998
III	3·0065
IV	3·0165
Average	3·0058

The values for the specific gravity are usually given in the various standard text-books* as varying from 2·9 to 3. Bauer,† however, gives 2·9–3·6. We have been unable to find any records whatever of datolites possessing a specific gravity as high as 3·6, and on account of the fact that the figures obtained by us on very pure material are much lower, we would question the correctness of the larger value given by Bauer.

In conclusion, we wish to express our indebtedness to Prof. E. D. Campbell, Director of the Chemical Laboratory of this University, for advice and suggestions relating to the chemical portion of this paper.

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of Michigan, Ann Arbor, Mich.
March 30, 1906.

* Dana, System of Mineralogy, 1892, 504; Hintze, Handbuch der Mineralogie, II, 167; Miers, Mineralogy, 1902, 588; Naumann-Zirkel, Elemente der Mineralogie, 14te Auflage 1901, 629.

† Bauer, Lehrbuch der Mineralogie, 2te Auflage, 1904, 762.

ART. VII.—*The Russian Carboniferous and Permian compared with those of India and America. A Review and Discussion;* by CHARLES SCHUCHERT. (With Plate I.)

CONTENTS:

Part I. The Work of Tschernyschew.
Part II. The Work of Noetling.
Part III. The Work of Diener.
Part IV. The Work of Girty in the Trans-Pecos Region of Texas.

PART I. THE WORK OF TSCHERNYSCHEW.

Die Obercarbonischen Brachiopoden des Ural und des Timan. Von Th. Tschernyschew. Mem. du Comité Géol., vol. xvi, 1902 [1903], pp. i–viii, 1–749, and 63 plates.

THIS large and exceedingly valuable monograph describes the brachiopods collected by the author and others during eight years in the Ural and two years in the Timan districts of European Russia. The great number of 213 species are described, and two new genera—*Keyserlingina* and *Spiriferella*.

In the present review of this monograph, the author's general conclusions regarding the occurrence of these forms in the various horizons and their significance in correlation only will be taken into account. In fact, Tschernyschew's correlations are of the first importance, and will be fully presented here.

In the introduction the author states: —

"It is my opinion that the exceptional richness of the fauna of the Upper Paleozoic sediments of Russia and the positive succession of the various horizons give us the right to regard eastern and northern [European] Russia as the starting point for the correlation of similar deposits in other countries. . . . Not infrequently my views differ from those of my colleagues in western Europe and America, and in recording these conclusions in the final chapter of my work my chief object has been to present the views of one geologist who in the course of many years has studied the upper Paleozoic deposits in the vast territory of Russia. It is very probable that some of my freely-stated assertions will be strongly criticized by geologists both at home and in foreign countries, and I shall be the first to greet such criticisms with pleasure" (pp. vi, vii).

Of the 213 species of brachiopods known in the "Upper Carboniferous" of Russia, 61 pass into the Artinsk zone and but 10 into the typical Permian. The latter are *Dielasma elongatum*, *Rhynchopora nikitini*, *R. variabilis*, *Camarophoria crumena*, *C. superstes*, *C. globulina*, *Athyris pectinifera*, *A. roissyi*, *Spiriferina cristata*, and *Productus* aff. *leplayi*.

These make it clear that this is not the normal marine fauna that continues the Paleozoic sequence into the Mesozoic. This point, however, will be discussed on a later page (see "Conclusions," paragraph 2).

In regard to the Russian faunas the author states :—

"I wish to call attention to the decided differences which make their appearance in the fauna of the Omphalotrochus horizon when contrasted with the type of that of Miatschkowo [near Moscow; also see the following table for stratigraphic position], and on the other hand the great resemblance of the brachiopod fauna of the Schwagerina zone to that of the higher lying Permo-Carbon (the Artinsk deposits CPg and the Limestone-dolomite CPc). In the lower Permian fauna of Russia we have already noted a decided reduction in Brachipoda, if not in quantity, at least in variety of species; and in the still higher horizons of the Russian Permian, the total number of Brachiopoda is not more than 40 species [this number has reference to all areas correlated with the typical Perm area]. Entire groups of forms . . . that give a decided aspect to the fauna of the Upper Carboniferous Artinsk, and the Limestone-dolomite beds, are completely unknown in the Permian sediments of Russia and west Europe. Some of these groups therefore attract our attention because they are foreign to the Permian deposits, yet in the Mesozoic (Trias and Jura) they attain an extended development. On the other hand, others belong to such original types as the Lyttoniidæ, *Tegulifera*, and *Orthotichia*, forms that give a decided character to the upper Paleozoic, and, so far as our knowledge goes, completely disappear with the Permian epoch [of western Europe]. From a biological standpoint there can be no doubt that our Upper Carboniferous brachiopod fauna has the facies of a younger type than the Permian, and that in its entirety it has a more decided Mesozoic impress than that of the [Russian] Permian following, which when compared with the other shows atavistic trends [see note 6]. As it is my opinion that this atavism finds its proper explanation in the physico-geographic conditions of the Permian sea, I hold that it is not superfluous to direct special attention to this fact, and thereby to moderate the tendency of some geologists, who in their determination of the age of this or that fauna depend mainly upon the biological peculiarities and not infrequently leave out of consideration the possible explanation that the biological differences between two synchronous or at least closely adjoining faunas are partially due to facies and chorological causes" (pp. 663–4).

"Although the data presented regarding the distribution of Upper Carboniferous deposits in the region of European

Russia show that we can not fix with certainty the exact shore-lines of the sea of this epoch, still from the general distribution and the nature of the sediments of this time, when compared with those of the Middle Carboniferous epoch, we may conclude that there was a retreat of the sea in the west. In the north the Upper Carboniferous sea had great extension and communicated freely with the far-reaching Polar sea. In the east it was limited by the Ural barrier, behind which in Siberia lay a series of more or less extensive basins of brackish or fresh water" (p. 679).

For the sake of completeness, the reviewer will here introduce a somewhat detailed generalized section of the Permian and Carboniferous of Russia, compiled from various recent sources:*

Brackish ?Permian or ?Triassic, Tartarian (PT).

Red grits, argillaceous sands, and intercalations of clay and marl of the same color; rarely green or bright blue.

Red colored marls and variegated clays, with intercalations of grayish grits and sands of the same tints.

These two groups have brackish-water genera, as *Unio*, *Anthracosia*, *Najadites*, and *Palæomutela*.

Permian (P) of Samara and Oufa (the Permian sensu-stricto of Murchison).

Brown grits, marls, and limestone.

Has some pelecypods, as *Allorisma elegans*, etc.

Gray slaty limestones, with intercalated marls and friable grits.

Has *Murchisonia subangulata*, *Turbonilla altenburgensis*, *Macrodon kingianum*, *Osteodesma kutorgana*, *Modiolopsis pallasi*, *Leda speluncaria*, etc. Of Crustacea, *Bairdia*, *Estheria*. *Lingula orientalis*. Of fishes, *Palæoniscus*, *Acrolepis*.

Grits and gray limestone, more or less copper-bearing.

Rich in brachiopods: *Spirifer regulatus*, *Spiriferina cristata*, *Athyris pectinifera*, *Dielasma elongata*, *Productus cancrini*, *P. hemisphæricus*, *Strophalosia horescens*. Some bivalves and corals.

Red argillaceous grits, with intercalations of clay and gray, brown, and reddish marls.

Fossiliferous only in the higher beds: *Productus cancrini*, *Athyris pectinifera*, *Dielasma elongata*, *Allorisma elegans*, *Macrodon kingianum*, etc.

*The Permian and Moscowian section is taken from Nikitin—"De Moscou à Oufa (via Miatschkowo, Riazan, Penza, Syzran, Samara)," Guide des Excursions, VII, Congrès Géol. Internat., 1897, Pt. II; the Uralian, from Tschernyschew's great brachiopod work here reviewed; the Viséian and Artinsk, from Tschernyschew, Mém. du Comité Géol., III, No. 4, 1889.

Argillaceous limestones and marls of variegated tints. No fossils.

Gypsiferous group of limestone, gypsum, and clay. No fossils.

Permo-Carboniferous, or Artinskian (Lower Permian of many authors).

Horizon CPc, or dolomitic-limestone zone. A gray or yellowish gray cavernous limestone passing often into dolomite, brecciated or conglomeratic in composition, with intercalated beds of oolite and occasionally shale.

Has a fauna smaller than, and almost identical with, that of horizon CPg. *Cladodus, Dielasma hastata, D. elongata, Spiriferina cristata, Rhynchopora nikitini, Chonetes variolaris, C. verneuiliana, Productus purdoni, P. cora, Marginifera typica, Fusulina verneuili,* and *Bradyina nautiliformis.*

Horizon CPg, or Artinskian *sensu stricto.* "Peppery" sandstone, with intercalations of shales. In places conglomerates, limestone, shales, and slates.

Has *Phillipsia gruenewaldti, Pronorites præpermicus, Agathiceras uralicum, Medlicottia artiensia, Gastrioceras, Popanoceras, Parapronerites.* Of Upper Carboniferous brachiopods, 61 species pass into this zone. Among the more prominent fossils of the zone are the following: *Dielasma elongata, Spirifer fasciger, S. alatus, Spiriferina cristata, Spiriferella saranæ, Rhynchopora nikitini, Camarophoria plicata, Streptorhynchus pelargonatus, Productus spiralis, P. lineatus, Marginifera typica, Fusulina verneuili.*

Upper Carboniferous, or Uralian.

Schwagerina zone (C^3_3), about 60 meters thick in Timan.

Abounds in *Schwagerina princeps.* Other Foraminifera are *Fusulina verneuili, F. longissima.* Of corals, there are many species, mostly of the compound type. Of Bryozoa, the most striking is *Archimedes.* This is the horizon *par excellence* for brachiopods, Tschernyschew recording 194 forms. *Dielasma* in greatest abundance, with 13 species; *Hemiptychina* 4, none below; *Notothyris* 3; *Aulacothyris* 2; *Keyserlingina* 2, none below; *Terebratuloidea* 2, none below; *Pugnax* 8; *Camarophoria* 14; *Spiriferina* 8; *Spiriferella* 4; *Spirifer* 21; *Martiniopsis* 7, none below; *Martinia* 13; *Reticularia* 4; *Meekella* 2; *Orthotichia* 1, none below; *Chonetes* 11; *Aulosteges* 1; *Productus* 40; *Proboscidella* 3 (these are not of the type of the Lower Carboniferous, having had another

origin); *Marginifera* 8. Pelecypods also common and of the ordinary Upper Carboniferous types. Of cephalopods, *Agathiceras uralicum*, *Pronorites cyclolobus uralensis*, *P. postcarbonarius*. Trilobites, *Griffithides roemeri* and *G. gruenewaldti*.

Productus cora zone (C_3^2), about 70 meters thick in Timan and 100 in southern Ural. The most abundant fossil is *P. cora*. Other brachiopods are *Dielasma*, 4 species (*bovidens*); *Camarophoria* 4; *Spiriferina* 2; *Spiriferella saranæ*, *Spirifer cameratus*, *S. condor*, *S. fasciger*, *S. marcoui* (goes no higher), *Derbyia regularis*, *D. crassa*, *Meekella striaticostata* and 3 other species; *Chonetes mesoloba*, *C. granulifera*, *C. flemingi*, *C. variolata*, *Aulosteges*, *Productus boliviensis* and 21 other forms, *Marginifera uralica* and 4 other forms. Corals are rare, especially the compound forms so common both above and below. *Archimedes* rare. Large *Fusulina verneuili*. *Griffithides scitula*.

Omphalotrochus zone (C_3^1b). This zone and the one below have a united thickness of about 70 meters. Most abundant fossil *Omphalotrochus whitneyi*. Of brachiopods there are *Dielasma itaitubense*, *Camarophoria* 3, *Spirifer marcoui*, *Derbya crassa*, *D. regularis*, *Meekella striaticostata*, *Aulosteges*, *Productus nebrascensis*, *P. cora*, *P.* 10 species, *Marginifera uralica*. Corals very abundant; this zone in the Urals is 12 meters thick.

Spirifer marcoui zone (C_3^1a).

Has an abundance of *S. marcoui* and corals.

Middle Carboniferous, or Moscowian (C_2), about Miatschkowo.

1. Greenish white fragmental limestone, ·3 meter thick.
2. Greenish compact argillaceous limestone, ·7 meter thick.
3. Yellow dolomitic limestone, $2\frac{1}{2}$ to 3 meters thick. Abounds in fish teeth and plates of *Cladodus*, *Dactylodus*, *Deltodus*, *Ostinaspis*, *Pœcilodus*, *Polyrhizodus*, *Psephodus*, *Psammodus*, and *Solenodus*. Also *Productus semireticulatus*.
4. Grayish compact limestone, $1\frac{1}{2}$ to 2 meters thick.
5. White granular soft flaggy limestone, 2 to 3 meters thick. Has a normal marine fauna. Those preceded by 1 are the characteristic species. Has many of the fishes found in 3, and *Cymatodus*, *Helodus*, *Orodus*, *Petalodus*, and *Tomodus*. Also *Nautilus mosquensis*, *Euomphalus pentangulatus*, *E. marginatus*, *Macrocheilus ampullaceous*, *Allorisma regulare*, *Conocardium uralicum*, *Productus cora* (*riparius*), *P. lineatus*, 1 *P. semireticulatus*,

P. longispinus, *P. punctatus*, 1 *Enteletes lamarcki*, *Meekella eximia*, 1 *Spirifer mosquensis*, 1 *S. strangwaaysi*, *S. fasciger*, and 1 *Seminula ambigua*. In the clay bands this is also the horizon for crinoids *Cromyocrinus*, *Hydriocrinus*, *Phialocrinus*, *Poteriocrinus*, *Stemmatocrinus*, etc. Also *Archiocidaris rossica*, *Lepidesthes*, and *Calliastes*. Several species each of *Fenestella* and *Polypora*. Of corals, *Bothrophyllum conicum*, *Petalaxis* and 1 *Chætetes radians*. Also *Fusulina cylindrica*, but not readily seen.

6. Fusulina limestone made up of Foraminifera and crinoidal matter, 1 meter thick.
   Has some of the fishes also found above, *Nautilus* 6 species, *Productus semireticulatus*, *P. punctatus*, *Meekella eximia*, *Enteletes lamarcki*, *Spirifer mosquensis*, *Archiocidaris rossica*, *Chætetes radians*, *Syringopora parallela*, *Bothrophyllum conicum*, *Axophyllum rossophyllum*, *Fusulina cylindrica*, *Bradyina*, *Endothyra*, *Fusulinella*, *Cribrostomum*, and *Tetrataxis*.
7. Yellowish white hard compact limestone, 1½ to 2 meters thick.
8. Dirty white limestone.

Lower (?) Carboniferous, or Viséian.

Upper limestone (C_1^2).
   Has *Allorisma regularis*, *Rhynchonella pleurodon*, *Seminula ambigua*, *S. subtilita*, *Schizophoria resupinata*, *Productus longispinus*, *P. corrugatus*, *P. pustulosus*, *Fusulina verneuili*, *Fusulinella sphæroidea*, etc.

Lower limestone (C_1^1).
   Has an abundance of corals, *Syringopora gracilis*, *Lithostrotion affine*, *L. cæspitosum*, *L. irregulare*, and brachiopods, *Productus giganteus* and *Chonetes papilionacea*. Also *P. striatus*, *Athyris squamigera*, *A. expansa*, *Martinia glabra*, *Phymatifer pugilis*, *Phanerotinus serpula*, *Phillipsia globiceps*, etc.

Devonian.

Correlations with India.

Tschernyschew regards it as "highly desirable to discuss in detail the section of the Salt Range, which, as far as the sequence of the horizons and their paleontological characteristics are concerned, is described more completely than is any other region of Asia. This area is at present not only the starting-point for the correlation of other Asiatic regions, but for the Austrian Paleozoic as well; hence I hold that my view regarding this profile will not be unacceptable" (p. 715).

Of the many Indian species of Brachiopoda, the author finds that 31 are also known in the Ural-Timan region. To these he has added 13 other species not common to both areas, but which clearly have related forms. He then discusses the distribution of these various species in the beds of India and the Ural-Timan region, and concludes:—

"Of great significance is the occurrence of the family Lyttoniidæ in the Schwagerina horizon of the Ural and the Virgal beds of India. This occurrence is of great moment and significance in the history of the upper Paleozoic of Russia" (see "Conclusion," paragraph 5).

"Through a comparison of the brachiopod fauna of the Upper Carboniferous deposits of the Ural and Timan with those of the various subdivisions of the Productus-limestone of the Salt Range, we clearly see that the lower Productus-limestone, or the Amb beds [see tables on pp. 32, 37], is more properly correlated with the Ural-Timan horizon having *Spirifer marcoui* and *Omphalotrochus whitneyi*, and that in our Schwagerina horizon we more naturally may discern the greater part of the Middle Productus-limestone, while the homotaxial sediments of the Cora horizon we have to seek in the upper layers of the Amb beds and probably also in the lower horizons of the Middle Productus-limestone, or in the Virgal group (according to Noetling's nomenclature). In this parallelism the Kalabagh beds [upper division of the Middle Productus-limestone] and the Upper Productus-limestone (in any event, the major part) well represent the Artinsk deposits and their equivalents of the Ural."

"This result is in the main at variance with the prevailing views as to the age of the various subdivisions of the Productus-limestone of the Salt Range, and approaches decidedly the original conclusion that the age of these beds is Carboniferous. I foresee that against my deductions the objection will be raised that they are based on a comparison of the brachiopods alone, but I can also defend them through other classes of the animal world. Moreover, I wish to say a few words in regard to the Cephalopoda, especially the ammonites." He then discusses the ammonites of Russia and Sicily, as described by Karpinsky and Gemmellaro, and lays particular stress upon the conclusion of the former, which he quotes as follows: "That the Sicilian fauna is somewhat earlier in origin than that of the Urals, although they, as I will again assert, approach closely the Artinsk. On the other hand, it is possible that the differences mentioned are due to chorological causes. The complicated Arcestidæ, for instance, can only belong to the southern regions" (pp. 719–20).

Because of the wide distribution of the remarkable fish *Helicoprion* in North America,* Japan, India, and Australia, and of the fact that in the Ural all the specimens of this genus are from the Artinsk horizon, Tschernyschew holds that these data should be given great weight, since so peculiarly constructed an animal "must have had a very restricted duration" (p. 722).

"According to my judgment all that has been said is strictly against the conclusion of Waagen and his adherents, who see in the Productus-limestone the entire Permian series of Russia. In the general chronological scheme the Productus-limestone has to take a deeper position than that assigned to it by Waagen, Noetling, and others" (p. 725).

Regarding Noetling's statement that the Productus-limestone passes without break into the Ceratite-bearing beds of the Triassic, Tschernyschew admits it to be "a very serious argument in favor of the intimate stratigraphic connection between the Trias and the Permian in the Salt Range, and the entire question relative to the discordance or transgressive nature of the beds appears to him [Noetling] impossible in such close association." Tschernyschew answers that the total dissimilarities in the faunas of the Productus-limestone and the Ceratite beds of the Triassic, which are separated by only a few meters (in fact not a single species passing from one into the other, according to Waagen), cannot be accounted for, as Noetling thinks, by the changeable nature of the sediments at this level. "Such a sharp paleontological boundary is, rather, testimony for a transgressive superposition of the Trias on the Paleozoic of the Salt Range." He then states that numerous Paleozoic and Mesozoic examples of supposed continuity, with very similar lithologic deposits, were later shown by the Russian geologists to be discontinuous and transgressive, with great chronologic differences. "With this I shall allow the matter to rest, adding the further statement that I believe the evidence cited by Noetling not to have the strength of sound proof in favor of a gradual replacement of the Permian sea in the Salt Range by the Trias, the sharp paleontologic boundary between these deposits indicating, rather, a transgressive superposition of the Scythian stage upon the Productus-limestone" (pp. 726–27).

As the Otoceras beds of the Himalaya, supposed to be transitional between the Productus-limestone and the Ceratites beds of the Salt Range, enter largely into the question whether the latter are not transgressive upon the former, Tschernyschew discusses the matter as follows:—

"What relation the zone with *Otoceras woodwardi* and *Ophioceras tibeticum* in the Himalaya bears to the section of

* This genus is unknown in North America, and the author probably has reference to the related type *Campyloprion lecontei* occurring in Nevada. See Eastman, Amer. Nat., June, 1905, pp. 405–409.

the Salt Range is a problem that still needs a final solution. Paralleling it with the upper horizon of the Upper Productus-limestone, the correlation is primarily based on the identity of *Medlicottia wynnei* Waag. of the Salt Range with *M. dalailamæ* Diener, which Krafft (A. v. Krafft, Ueber d. perm. Alter d. Otoceras-stufe des Himalaya. Centralbl. f. Min., Geol. u. Pal., 1901, pp. 275–279) says represent but one species. However, as Waagen's original specimen is, according to Krafft, very badly preserved, this stated identity requires better material for its proof. It is all the more necessary to be careful, because in the Artinsk beds of Russia were found Medlicottias that much remind one of *M. wynnei* Waagen. In any event, before the correlations of Noetling (Neues Jahrb., Beil.—Bd. XIV, table facing p. 468) can be accepted it is necessary to prove an uninterrupted paleontological connection from the zone with *Cyclolobus oldhami* and *Hemiaspis carbonarius* to the beds with *Otoceras woodwardi*" (p. 727. See Noetling's recent work on the Otoceras beds of the Himalaya here reviewed).

Tschernyschew states that until the entire Permo-Carboniferous fauna of Russia is worked out, no positive correlation can be made, but for the present the equivalent as presented in the following table is the most probable (p. 728):—

	Salt Range		Ural and Timan
Upper Productus-limestone	Chideru beds Jabi beds Khund-Ghat beds	Chideru of Noetling	Lower Permian of European Russia
			Limestone-dolomite horizon CPc and Artinsk beds CPg
Middle Productus-limestone	Kalabagh beds Virgal beds Katta beds	Virgal of Noetling	Schwagerina zone, 50 to 60 meters
Lower Productus-limestone	Amb beds of Waagen and Noetling		Cora zone, 70 to 100 meters
			Omphalotrochus zone Spirifer marcoui zone } 60 to 70 meters
	Warcha beds (Speckled sand and Lavender clay) Dandote beds Talchir bed (Bowlder clay)	Pendschat of Noetling	Middle Carbon with *Spirifer mosquensis* of the east slope of Urals Conglomerate and breccia of east slope of Urals

Correlation with America.

Tschernyschew regards the McCloud limestone of the Shasta, California, region as the homotaxial equivalent of the Omphalotrochus horizon of the Ural and Timan. Further, he agrees with Professor Smith that this limestone is to be referred to the Lower Coal Measures. The fossils of the lower beds of the Pitt formation "remind one mostly of the Cora horizon of the Ural and Timan." "As to the analogues of the Schwagerina horizon it is difficult to state anything positively, although the extensive Pitt shales (about 2000 feet) may in part represent these beds of the Ural and Timan" (p. 700). Concerning the Robinson beds of Diller he states that "their age is near that of the Ural-Timan Cora zone."

Regarding Cummins's Texas section, this author says: "With some probability the Canyon and Strawn beds may be considered as analogous to our Ural-Timan Cora horizon, the Cisco and Albany beds to the Schwagerina zone. This is seen in the interesting paleontologic data obtained by Cummins and White in the Wichita and Clear Fork beds which overlie the Albany formation. The fauna gathered in the upper portion of the Wichita and in the lower part of the Clear Fork according to its development may be regarded as near that of the Artinsk of east and north Russia" (p. 702).

According to Prosser's work, Tschernyschew correlates the Kansas sections as follows: "The Wabaunsee and Cottonwood beds I have seen while on an excursion in Kansas in 1891, the former in the railroad quarry at the station Manhattan, and the latter in the Ulrich quarry in the same village. I should prefer to correlate both with the Cora horizon of east and north Russia. The Neosho beds and probably also the lower portion of the Chase series appear to be analogous with the Schwagerina horizon of Russia, and the remainder of this as well as the Marion beds must be regarded as homotaxial with the Russian Permo-carbon and the lower Permian. Finally, the Wellington and Cimarron beds may represent the lower red colored Permian series of east and north Russia" (p. 703).

"In Missouri and Iowa the character of the Upper Carboniferous sediments approaches the type developed in the Donetz basin,* and as in this region of Russia so in these states the Coal Measures were deposited in a relatively great sea closed toward the east, north, and south, that had connection only in

* For a detailed exposition of the Lower (C_1), Middle (C_2) and Upper (C_3) Carboniferous lithological and biological sequence, see Tschernyschew and Loutonguin, in Le Bassin du Donetz (Guide des Excursions, VII, Congrès Géol. Internat., 1897, Pt. XVI).

the west and southwest with that of the widely extended Upper Carboniferous sea of western North America." The Mississippian series "represents the entire lower and in all probability also a portion of the Middle Carboniferous divisions of Russia. . . . As has been stated above, the Wabaunsee beds are to be regarded as near the Cora horizon; we can not therefore ascribe a younger age to the Des Moines series, and they are in all probability at least in part equivalent to the Omphalotrochus horizon" (pp. 704–5).

"The Donetz type of sedimentation is still more typical in the profiles of the states Illinois, Ohio, and Kentucky. . . . At present one can only point out that a portion of the Upper Coal Measures of these States in all probability represents the beds of the Donetz basin, which on the basis of the latest researches may be regarded as the analogues of the Artinsk deposits of the Urals."

Tschernyschew then sums up his conclusions in the following table:—

Ural and Timan	California, Nevada, Utah, and Colorado	Texas and Arkansas	Kansas, Nebraska, Iowa, Missouri	
Artinsk deposits	Shale and shaly limestone of the Wasatch Mountains and their pelecypod fauna	Wichita and Clear Fork beds	Marion beds Chase beds	
Schwagerina horizon	Light colored limestone of the Upper Carboniferous	Albany and Cisco beds	Neosho beds	
Cora horizon	Lower portion of Pitt shale series. Robinson beds. ? Weber quartzite		Missouri series and Cottonwood beds of Kansas and Nebraska Wabaunsee beds Oread limestone and Osage shales of Kansas	
Omphalotrochus horizon	McCloud limestone Upper portion of Wasatch limestone	Canyon and Strawn beds	The series from Garnet to Oswego limestones of Kansas	Des Moines beds of Missouri

In this connection, it may not be amiss to give the opinion of one who has now devoted ten years to a study of American Carboniferous faunas, and who has had the great advantages of the U. S. Geological Survey,—Dr. George H. Girty.

"Tschernyschew also correlates the Russian section with that of the Mississippi Valley. His correlation may be correct, but the Pennsylvanian faunas of the latter area are so widely different from those of our Western States which the Russian ones most closely resemble, that, in the opinion of one who has had some acquaintance with both types, a precise correlation is, in our present knowledge, impossible. The beds placed in alignment by Tschernyschew contain faunas so widely dissimilar that it seems an act of temerity to group them together. The evidence for so doing consists in part of the occurrence of certain American species in the Russian faunas, but the identifications, if one may judge by the figures given, in some cases are questionable and in others consist of such long-ranged types that in view of the really small percentage which these forms bear to the entire fauna, the evidence appears of diminishing significance the more critically it is examined" (3, p. 24).

Part II. The Work of Noetling.

1. Ueber das Verhältniss zwischen Productuskalk und Ceratitenschichten in der Saltrange, Indien. Von Fritz Noetling. Centralblatt für Min., Geol. und Pal., 1904, pp. 321–327.

2. Ueber Medlicottia Waag. und Episageceras n. g., etc. Von Fritz Noetling. Neues Jahrb., Beil.-Band XIX, 1904, pp. 334–376.

3. Ueber das Alter der Otoceras-Schichten von Rimkin Paiar (Painkhanda) in Himalaya. Von Fritz Noetling. Neues Jahrb., Beil.-Band XVIII, 1904, pp. 528–555.

The first of these papers is a short summary of an earlier, very important and extensive discussion by the same author (4. *Beiträge zur Geologie der Salt Range*, etc., Neues Jahrb., Beil.-Band XIV, 1901, pp. 369–471), describing the sequence of the horizons closing the Paleozoic and their unbroken succession into the well-developed Lower Triassic of India. Noetling's work has been assailed by one of the foremost geologists of Europe, and as the proper correlation of the Productus-limestone with European horizons affects the various formations composing the Permian system, it is well for Americans to become acquainted with these latest works, especially since Asiatic faunas are now known in southwestern Texas, California, and Alaska.

Noetling states: "Upon the Cambrian beds of the Salt Range there lies discordantly a sedimentary complex, followed by a series that Koken has established as of Jurassic age, in which there is no evidence of discontinuity, although during its deposition at various times very different physical conditions must have occurred.

"On the basis of origin, one can separate this sedimentary complex into three divisions of varying thickness, namely:

"An upper, pure marine
"A middle, glacio-marine } division.
"A lower, glacial

". . . This arrangement is intended only to express the relative participation of ice and sea-water in these deposits. Nowhere do we see a stratigraphic break or discordance; through local intercalations of drift horizons, the lower glacial deposits, the stratified beds, and the Conularia layer are closely united with the glacio-marine division (Olive-sandstone and Lavender-clay), and from the latter there occurs a very gradual transition into the pure marine division.

"Again, three very unequal faunal divisions may be distinguished, namely:

"An upper division: characterized by an abundance of Ceratites.

"A middle division: characterized by an abundance of Paleozoic brachiopods and sparingly of Ammonites.

"A lower division: thus far without such fossils.

"These three faunistic divisions do not wholly agree with the three genetic sections. The lower division without fossils is of course in harmony with the glacial division, but the middle section embraces the glacio-marine and the lower portion of the marine divisions, while the upper member includes the upper part of the marine section. The following table will make this clear:—

"Genetic divisions	Faunistic divisions		Stratigraphic divisions
Pure marine beds	Characterized by the absence of Paleozoic brachiopods and the appearance of a great abundance of Ceratites	Paleozoic brachiopods absent. Ceratites occurring in abundance	Ceratite beds
	Characterized by the retreat of the Ceratites and the appearance of an abundance of Paleozoic brachiopods	Paleozoic brachiopods abundant. Ceratites rare	Productus limestone
Glacio-marine beds		Paleozoic brachiopods unknown Conularia fauna	Lavender-clay / Olive-sandstone
Glacial beds	Without fossils	Without fossils	Bowlder clay"

"The stratigraphic divisions represent the four or five great natural groups into which the Permian system of the Salt-Range is readily divisible, on the basis of the paleontological, lithological, and genetic characteristics."

"Naturally of greatest importance are the two groups of the upper marine division—the Ceratite beds and the Productus-limestone—for if the age of either of them can be satisfactorily determined, it follows that the age of the other is also fixed. In a general way, the age of these two groups is already established: The Productus-limestone, with its very remarkable abundance of Paleozoic Brachiopoda, must belong in the Paleozoic, while the Ceratite beds having the Ammonites characterized by Ceratite suture lines must be referred to the Triassic. However, the Productus-limestone was regarded as Carboniferous until the detailed description of the fauna by Waagen taught that this view must be decidedly modified. On my first trip to the Salt Range I noticed the gradual transition from the Productus-limestone into the Ceratite beds at Chideru; later I was able to extend this observation through the profile in the Chuas. ravine, near Virgal; here can be plainly seen the individual lithologic members of the Productus-limestone and the Ceratite beds in most intimate succession. . . . Because of the indisputable succession at these two places I argued as follows: Such an intimate connection of Paleozoic and Triassic can only exist near the dividing line between the Permian and Triassic; if the Ceratite beds belong in the Triassic, then the underlying Productus-limestone must fall into the Permian, and accordingly, on account of the individuality of its fauna, it must represent but a single division of the Permian, but can not at the same time be the equivalent of both the Zechstein and the Rothliegendes."

The author then makes comparisons with other Indian Triassic regions, and also discusses the possibility that the Productus-limestone may be Upper Carboniferous. He concludes that if the Ceratite beds of the Salt Range are not Triassic, then the entire lower Trias is absent in the Himalaya. He maintains that the possibility of the Triassic being transgressive upon the Upper Carboniferous is excluded, because the transgression would then fall in the middle of an undisturbed sequence, i. e., in the Upper Productus-limestone. Further, if these deductions are not correct, then no reliance can be placed on the development of the suture lines of ammonites for the determination of geologic age (see below for his conclusions resulting from his studies on *Medlicottia*).

Noetling holds that there was a faunal transgression from the Urals, but that the time of its spreading was at about the middle of the Permian. "While this fauna was expanding radially, one can readily believe that the peripheral parts of

the transgression were younger than those of the pivotal region. In transgressions, one has to calculate not only with two dimensions, but also with a third, because a species may occur in geologically older beds near the center than at the periphery, where it may be found unchanged in younger deposits. . . . . It may be assumed that at the time of the Upper Carboniferous in the region of the present Urals, there existed an extended ocean, whose boundary was pushed toward the south and southeast (Uralic transgression). This transgression was not of a catastrophic or sudden nature, but was slow and continuous through a long period of time. The fauna spreading with the transgression passed, at least in part, unchanged into younger deposits; while in the outermost boundaries of the transgression, in the Salt Range and in the Himalaya, there occurs a series of forms in beds that are younger than the same species found in the central region. This crudely stated hypothesis naturally collides, of course, with the theory of guide-fossils (Leitfossilien), but my long-continued studies in India, namely, in respect to the Tertiary fauna, have more and more convinced me that the rigid theory of guide-fossils, valuable as it is within restricted areas, always proves disappointing when applied to greater, more widely extended regions."

In the author's larger work of 1901, cited above (4), he fully presents his views regarding the sequence of the Indian Permian and Triassic sections and their correlation with that of Europe. Noetling, however, recognizes that the difficulties are great, for he states: "If the Permo-Triassic formations of the Salt Range had first been studied, it would never have occurred to anyone to draw a line in this unbroken series and to apply to the divisions two names. One would have regarded the series as a unit, which it is. . . . . If from these formations one had proceeded to seek the European equivalents, they would have been hard to force into the scheme framed for the Salt Range. Speculation of every sort would probably have been resorted to. I now find myself in an analogous position in forcing into the European scheme the Permo-Triassic series of the Salt Range, and if it is to be employed in this case then one must make a purely artificial separation" (4, p. 458).

From this work, the table of Plate I is compiled, giving the sequence of the formations, their terminology, thickness, and correlations with European standards; the Himalayan section is added from Noetling's paper here numbered 3.

The second of these papers cited deals with the very important Permian ammonite *Medlicottia*. The genus is here studied in considerable detail and comparisons are made between the European and Indian species. The American forms are

not discussed, these being left to Prof. James Perrin Smith. In regard to the stratigraphic and evolutional conclusions attained by the author, he states:

"The views here presented are proved partly by ontogenetic, partly by phylogenetic examinations and observations, and therefore they may to a certain extent be depended upon. I must, however, note the assumption on my part that the Sicilian Fusulina-limestone is older than the Artinsk [=Permo-Carb. of the Russians] horizon, and again that the latter is older than the Productus-limestone of the Salt Range. By following out this assumption and comparing the various suture lines with one another, I obtained positive results which were proved by the development of the suture lines of *M. orbignyana*. This especially applies to the divisions of the external saddles" (p. 354).

"In this connection I would [first] like to point to an observation, which in spite of its scantiness permits of wholly unsurmised deductions regarding the climatic conditions at the close of Paleozoic and the beginning of Mesozoic time. In an earlier work I had the opportunity of propounding the question—Is the abundant appearance of *Productus* possibly connected with a cooler temperature of the sea-water?" [In Neues Jahrbuch, 1896, II, p. 86, this problem is stated as follows: "In India at least, but more particularly in the Salt Range, there was a glacial period at the beginning of Permian time. It would be interesting to examine the evidence to see if the great abundance of *Productus* has any connection with the cooler temperature of the sea-water."]

"A greater knowledge of the Paleozoic deposits of the Salt Range has given undoubted evidence of the existence of a Glacial Period at the beginning of Permian time, which deposits locally were laid down in the sea. [For a full bibliography and a good description of the late Paleozoic glaciation of India, see Noetling, Neues Jahrb., 1896, II, pp. 61–86.] In other words, this sea must have been one with a low temperature. Subsequently, in this sea was deposited the Productus-limestone, and the conclusion is not probable that the temperature of the water rose during the melting of the glaciers and the introduction of the *Productus*-fauna. In the Salt Range, therefore, this fauna is to be regarded as an arctic one.

"The studies of *Medlicottia* have shown that *M. primas* Waag. is in all probability to be regarded as a descendant of *M. orbignyanus* Vern. sp. of the Artinsk horizon. One can picture to himself the condition whereby the Medlicottias migrated from north to south (more correctly from northwest to southeast) at the same time that they passed into higher beds.

"If this conclusion is correct, i. e., the fact that a migration of the Ammonite world from north to south took place toward the end of the Permian, then, I ask, is it not conceivable that the *Productus*-fauna accustomed to a cold sea was, in consequence of the raising of the general temperature of the water, driven from its original northern habitat toward the south, where shortly before the disappearance of the Permian ice period it found the required normal temperature? Is it not further conceivable that, with a continued increase in the temperature of the sea, which under some circumstances may have occurred very rapidly, the Brachiopod fauna, also, may here have been suddenly exterminated, while the Ammonites, apparently better adapted to warmer water, developed in a most remarkable manner? Is it not, moreover, conceivable that the end of Paleozoic time was characterized by a probable rapid increase in temperature which spread itself from north to south? If this hypothesis is correct, we must then assume that the dividing line between Paleozoic and Mesozoic time is marked by a change of temperature which spread from the northern hemisphere, thus forcing the Paleozoic Brachiopoda southward, where for a short time in a suitable medium,—a sea cooled by the Permian glaciers, they attain a wonderful development, and then die out when the average temperature exceeded that beneficial to them" (pp. 375–6).

These suggestions of Noetling's are of the greatest interest. However, as *Medlicottia* occurs in Texas in association with an undoubted Upper Carboniferous fauna of the type so well known in the Mississippi valley, the question arises—Are not these the oldest Medlicottias? If so, then the further question is raised—Was not the migration east and west through the great mediterranean Thetys instead of from north to south? In 1901, Noetling (4, p. 457) explains this change of fauna on the basis of change in the depth of the sea. He states: "The Brachiopoda of the deeper waters died out and are replaced by the Ammonites, lovers of shallow waters and flat coasts."

It is the impression of the reviewer that, until more is known in regard to the extremely interesting Productus-limestone fauna of the El Paso, Texas, region and similar or Artinsk faunas from California and Alaska, no safe deductions as to paths of migration can be made.

From the third paper by Noetling, on the Otoceras horizon, is gleaned the following:—

"In a treatise on the divisions of the pelagic Trias, Mojsisovics, Waagen, and Diener, supported by the statements of Waagen that there exists a hiatus in the Salt Range between the uppermost Permian and the lowest Trias, have denied the

existence of the Otoceras beds or their equivalents in this part of the Trias sea.

"I had serious doubts about this conclusion, for on my visit to Chideru in the Salt Range I was convinced that there is here a gradual transition from the Upper Productus-limestone (Permian) to the Ceratites beds (Trias).

"This observation is not new, for at different times Wynne has pointed out the gradual passage in the sequence of the beds from the Productus-limestone to the Ceratites beds, but his statements have unfortunately received too little attention" (p. 529).

On this visit Noetling looked for the Otoceras beds at the base of the Ceratites zone below the Ceratites-limestone, but did not find this diagnostic fossil. To his great surprise he did find what he took to be an *Otoceras* in the Ceratites-shale, i. e., above the Ceratites-limestone. On his return to the museum at Calcutta, however, the fossil proved not to belong to this genus. After a further dissection of the Himalaya section he states: "In the Himalaya the Otoceras beds lie immediately below the Hedenstroemia beds. Accordingly, in the Salt Range, either the Otoceras beds or their equivalents must be looked for immediately beneath the Ceratites beds. As, however, in the Salt Range, immediately beneath these beds lies the Permian (Upper Productus-limestone = Chideru group) it follows that we have to seek for the equivalents of the Otoceras beds in the Salt Range in the Upper Productus-limestone, probably in my *Euphemus indicus* zone, but over the zone with *Episageceras wynnei*." In spite of careful collecting none were found, and he concludes: "According to our experience we almost doubt the occurrence of *Otoceras* in the region of the Salt Range." The two regions have a different stratigraphic sequence with somewhat different faunas, and it may be that they were separated from one another by a submerged barrier (a rising anticline) not wholly preventive of intermigration.

Then follows a long discussion or the apparently complete transition zone in the Himalaya, between the Productus-limestone and the Ceratites beds, and considerable detail regarding the included fauna as well. This discussion is entirely too long and too detailed to be summarized here, but Noetling's views are clearly presented in two correlation tables, one of which has been added to the table given on Plate I.

[To be continued.]

PLATE I

HORIZONS AND ZONAL NAMES

			Salt Range			Himalaya	
			Discordance			Region of Spiti	Region of Niti
Triassic	Bunt-sandstein	Upper	Upper Ceratite limestone	Zone of *Stephanites superbus*	Maximum thickness	Not known as yet	Dark limestone of Byans
	Scythian stage	Middle	Ceratite sandstone	Zone of *Flemingites flemingianus*	220′	Hedenstroemia beds	Hedenstroemia beds
			Ceratite clay	Zone of *Koninckites volutus*			
				Zone of *Prionolobus rotundatus*			
		Lower	Lower Ceratite limestone	Zone of *Celtites* (?) sp.		Zone of *Meekoceras lilangense*	Zone of *Prionolobus noetlingi*
Permian	Marine Neodyas	Thuringian stage	Chideru group or Upper Productus-limestone Brown earthy limestone	Zone of *Euphemus indicus*	300′	Zone of *Ophiceras tibeticum*	Zone of *Ophiceras tibeticum*
				Zone of *Episageceras wynnei* 50′		Zone of *Otoceras woodwardi*	Zone of *Episageceras dalailamæ*
				Zone of *Bellerophon impressus*			Zone of *Otoceras woodwardi*
				Zone of *Cyclolobus oldhami* 180′			
				Zone of *Derbya hemisphaerica*		Dark Productus slates with *Cyclolobus oldhami*	Dark Productus slates with *Productus abichi*
				Zone of *Productus lineatus* 70′			
	Marine Palaeodyas	Zechstein	Virgal group or Middle Productus-limestone Light colored flinty limestone	Zone of *Xenodiscus carbonarius* 20′	300′		
				Zone of *Lyttonia nobilis* 130′			
				Zone of *Fusulina kattaensis* 50′			
				No *Fusulina* occur higher than this stage			
			Amb group or Lower Productus-limestone Dark, sandy limestone	Zone of *Spirifer marcoui* and *Fusulina*	200′		
	Glacial Palaeodyas	Pandschabian stage	Warcha group	Lavender clay Speckled sandstone	250′		
	Rothliegendes		Dandote group	Olive sandstone Zone of *Conularia laevigata* } In shale Zone of *Eurydesma globosum* } Olive sandstone	200′		
			Talchir group	Bowlder-clay	150′		

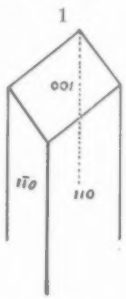
Discordance
Cambrian

Himalaya	
Region of Spiti	Region of Niti
Not known as yet	Dark limestone of Byans
Hedenstroemia beds	Hedenstroemia beds
Zone of *Meekoceras lilangense*	Zone of *Prionolobus noetlingi*
Zone of *Ophiceras tibeticum*	Zone of *Ophiceras tibeticum*
Zone of *Otoceras woodwardi*	Zone of *Episageceras dalailamæ*
	Zone of *Otoceras woodwardi*
Dark Productus slates with *Cyclolobus oldhami*	Dark Productus slates with *Productus abichi*

ART. VIII.—*Note on two interesting Pseudomorphs in the McGill University Mineral Collection;* by R. P. D. GRAHAM, B.A.

1. *Pseudomorphs of Orthoclase after Laumontite from Templeton, Ottawa County, Quebec.*

THE specimens described below were collected some years ago by Dr. B. J. Harrington in the apatite region of Templeton, and had been labelled by him as pseudomorphs after laumontite, although they were not further examined at the time. They consist chiefly of flesh-red to almost white crystals, measuring up to about half an inch in length for the most part, and having a very fresh appearance. the edges being quite sharp and the faces smooth with a dull and somewhat waxy lustre, although in some cases they are somewhat weathered on the surface. They are of the usual laumontite habit (fig. 1) showing a combination of monoclinic prism with basal plane. The faces do not directly yield reflections owing to their dull lustre, but by placing a drop of alcohol on each in succession, after adjustment on the reflecting goniometer, and taking readings at the moment when the drop is just about to disappear (as suggested by H. T. Whitlock*), the angles can be measured with a fair degree of accuracy, and they were found to correspond with those of laumontite. The crystals are implanted in irregular groupings in a compact material of a rather paler tint, but possessing the same general characters, and this in turn encrusts the dark green pyroxene and brownish phlogopite which are characteristic of the Templeton locality. The pyroxene is in the form of large prismatic crystals, an inch or so in diameter, and both this mineral and the phlogopite are more or less completely coated with a layer a quarter of an inch thick of the pale-colored massive material from which the pseudomorphous crystals spring; there are also dispersed through it fragments of a pale green apatite, and in one of the specimens, a crystal of zircon. The prism faces of the crystals are usually striated vertically and sometimes exhibit a step-like structure along the directions of the original laumontite cleavages, which, however, are now entirely lacking. The fracture is fairly even, and the crystals are solid and homogeneous throughout; in physical characters they correspond exactly with the feldspar: H = 6, Sp. G. = 2·56. Thin splinters fuse B. B., the pink color fading to white; and



* N. Y. State Museum Publication, 1905.

only a slight trace of water is given off on heating in a closed tube. The finely powdered mineral is insoluble in acids, and a preliminary examination of the solution obtained after fusion with a mixture of sodium and potassium carbonates showed that it contained no fluorine or chlorine. An analysis was made of material selected from some of the freshest crystals with the following result (column I):

	Templeton. I.	Weissig. II.	Orthoclase. III.
SiO_2	63·12	65·00	64·7
Al_2O_3	19·83	19·54	18·4
Fe_2O_3	0·67	——	
CaO	——	0·19	
MgO	0·24	1·61	
K_2O	15·13	12·69	16·9
Na_2O) Li_2O)	0·52	0·56	
Ign.	0·89	0·35	
	100·40	99·94	100·0

The sodium and lithium, which are present in only very small amount, were not separately determined, but the presence of both was shown by a spectroscopic examination of a solution in hydrofluoric acid. In containing a small percentage of lithium, this occurrence resembles the original weissigite from Dresden, the result of an analysis of which by Jenzsch is given above for comparison (column II).

The crystals are therefore pseudomorphs of orthoclase after laumontite and the compact material in which they are embedded doubtless had a like origin.

Although such pseudomorphs have not been described before from a Canadian locality they have been found in several other districts, and the following account of some of these occurrences is taken mainly from Blum's treatise on pseudomorphs.*

In 1853, Jenzsch† examined a mineral which occurs at Weissig, near Dresden, and which he found to have the composition of an orthoclase with a content of about one-half a per cent of lithia (see his analysis quoted above) as well as the general characters of a feldspar, the hardness being 6 and the specific gravity 2·55: these facts, together with the characteristic form of the crystals, combinations of monoclinic prism with basal plane, led Jenzsch to regard the mineral as a distinct species, to which he gave the name *weissigite* in reference to the locality at which it occurs. Weissigite, however,

* Die Pseudomorphosen, II, 20; III, 60.
† N. Jahrb. f. Min., 396, 1853; 405, 1854; 800, 1855.

is found in a porphyritic amygdaloid, associated with quartz and chalcedony, conditions under which a feldspar had never been known to occur up till that time; this, and the similarity of the form and habit of the crystals to laumontite subsequently convinced Jenzsch that the orthoclase was not a primary mineral in the amygdules, but that weissigite is in reality a pseudomorph of orthoclase after laumontite, which was the view held by Blum.

Similar pseudomorphs are mentioned by Blum as occurring at Niederscheld, near Dillenburg in Nassau. Flesh-red crystals of the common laumontite habit are dispersed through the greenstone, associated with quartz, which often completely envelops them; calcite and prehnite are also present in small quantity. The prism faces of the crystals are striated vertically, and the crystals are often more or less split along the directions of cleavage of the original laumontite: the alteration to orthoclase is seldom complete. Specimens of the same kind are also found at Schelder Eisenwerk, and at Oberscheld, where crystals an inch in length occur in a druse.

At Beilstein whole druses of pseudomorphs of orthoclase after laumontite occur in an altered diabase; the crystals, which are sometimes more than an inch long, have their original form well preserved, and show the usual striæ and cracks along the prism faces; and their pseudomorphous nature is also evident from the hollowness of many of the crystals. There is an almost identical occurrence at Conradsreuth, between Münchberg and Hof in Fichtelgebirge.

Laumontite is among the minerals found in the Lake Superior mining region of Michigan, where it occurs in clefts, coated, often completely, by calcite, and sometimes also by native copper. The laumontite is weathered and shows various stages of alteration, and has been analyzed by Lewinstein* with the following results; I refers to a brownish laumontite which readily crumbles, breaking along the cleavage directions, whilst II is of a more weathered material which has become firm and hard, and no longer possesses cleavage.

	I.	II.	Laumontite.
SiO_2	57·92	55·21	51·1
Al_2O_3	10·19	22·58	21·7
Fe_2O_3	1·19	2·55	
CaO	4·59	0·98	11·9
MgO	1·13	1·31	
K_2O	2·58	3·41	
Na_2O	1·14	3·45	
H_2O	21·26	10·51	15·3
	100·00	100·00	100·0

* Zeitschr. f. Chem. u. Pharm., iii Jahrg., 1860, p. 11.

These analyses were made by dissolving as much as possible of a weighed quantity of the mineral in acid, and calculating the results up to 100 per cent after deducting the weight of the insoluble residue. Hence they do not show the actual composition of the material taken, although they serve to indicate that the percentage of lime falls off more and more as the alteration proceeds, as also does that of the water once the hardening of the material has commenced, whilst the alkalis make their appearance in increasing quantities, rendering probable the assumption that the crystals are partial pseudomorphs of feldspar after laumontite. Sharp, well formed crystals of adularia, exhibiting the forms {110}, {001}, are also found at Lake Superior, situated on calcite and native copper, and these have also been regarded as probably due to the alteration of laumontite. On the other hand, J. D. Whitney* has called attention to the very common occurrence of orthoclase in all the mines of this region; he describes the crystals as being rarely more than a few hundredths of an inch in length, of a reddish color, arranged in bunches and geodes, and accompanied by native copper and the zeolites, the usual vein minerals of the region. From a consideration of the relative manner in which these minerals are associated with one another, Whitney concluded that in this case the orthoclase was formed contemporaneously with the accompanying minerals, and that it is not a pseudomorphous product of the zeolites; from which it would appear that orthoclase does occur in the veins at Lake Superior as a primary mineral, associated with the zeolites, etc., although, at the same time, the adularia crystals referred to above may have had a different and secondary origin, as Blum has suggested.

It is doubtful whether orthoclase has ever been found replacing laumontite at any of the well known Scotch localities for that mineral, notwithstanding the fact that such pseudomorphs have been described or referred to by several authors. In 1848, Haidinger† examined a number of altered zeolites from Allan's collection in Edinburgh, among which were some flesh-red crystals having the angles of laumontite but the hardness (6) and the specific gravity (2·5 to 2·8) of feldspar; the crystals had drusy surfaces and were ill-defined, and in addition were frequently hollow or else filled with a dark green stony material. These specimens were found in the trap rock, associated with quartz, at the Kilpatrick Hills, near Dumbarton, and also at Calton Hill, Edinburgh. Haidinger described them as pseudomorphs of feldspar after laumontite, apparently relying on qualitative tests in their determination, since he

* This Journal, xxviii, 16, 1859. † Sitz. Akad. Wien, iii, 95, 1848.

gives no quantitative analysis of the material in the paper referred to. It is quite possible, however, that they were pseudomorphs of albite, and not orthoclase, after laumontite; and Greg and Lettsom quote an analysis by Heddle of such pseudomorphs from Kilpatrick, which have the composition of a soda feldspar containing about one per cent of potash. Hintze, however, under *orthoclase*, mentions pseudomorphs after laumontite as occurring at Kilpatrick, and in the same paragraph refers to an analysis by Bischof which he appears to suggest was made on material from this locality. The same analysis is given by Blum, although that author does not expressly state where Bischof obtained his specimens, and on referring to Bischof's original paper* I find the same uncertainty exists even there, as it is not at all clear where the material he analyzed came from. The additional fact that Greg and Lettsom make no mention of pseudomorphs of orthoclase after laumontite in their *Mineralogy of Scotland* which appeared in 1858, several years after these observations of both Haidinger and Bischof, lends considerable probability to the view that such pseudomorphs had not at that time been found in Scotland, but that in all the observed cases the replacing mineral had been albite; nor are pseudomorphs of orthoclase after laumontite included in the list of *British Pseudomorphs* published by Prof. Miers† in 1896. However, a variety of orthoclase does occur at Kilpatrick, which was named *erythrite* by Thomson‡ in allusion to the flesh-red color; this he described as a compact feldspar, which he never observed in crystals, but there is nothing in his description to suggest that this was of a pseudomorphous nature.

It will be seen from the foregoing that pseudomorphs of orthoclase after laumontite are of fairly wide occurrence, although in the specimens from many of the localities the alteration seems to be incomplete, and the crystals often more or less hollow; but in the case of the specimens from Templeton described in this note, the crystals are invariably quite solid and compact, and, except in the form, show no trace whatever of a former existence as laumontite material. In this complete alteration to orthoclase, and, further in the small content of lithium, the mineral resembles the original *weissigite*.

The reverse change, from orthoclase to laumontite, has been observed from at least one locality, the Höllenstein-Klamm, Florenthals, Tyrol, where more or less altered adularia crystals, usually coated with chlorite, are found.

* N. Jahrb. f. Min., 43, 1850.
† Min. Mag., xi, p. 263.
‡ Phil. Mag., xxii, p. 188, 1843.

2. *Pseudomorph after corundum from Perth, Ontario.*

The specimen here described is an unusually large and well developed crystal of which a photograph is reproduced (fig. 2); it is about 5 inches in length and the prism has a diameter of 2 inches. At first sight it somewhat resembles a crystal of

2

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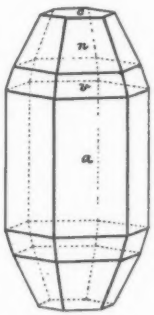

black quartz with rough surfaces, the predominant forms being the hexagonal prism and bipyramid, but it is terminated at one end by a fairly flat basal plane. It is also found, on closer inspection, that the edges between the prism and pyramid are truncated by faces belonging to a steeper pyramid, although these can scarcely be distinguished in the photograph; the lower end of the crystal presents a somewhat blunted appearance. The various angles were measured by means of the hand goniometer, and were found to be those of a corundum crystal, the forms present being:—a $\{11\bar{2}0\}$, n $\{22\bar{4}3\}$, c $\{0001\}$, and v $\{44\bar{8}3\}$ (fig. 3).

The crystal is almost entirely coated with black tourmaline, usually as a compact granular layer forming a fairly smooth surface; but sometimes the grains are more distinct and have bright facets, by which the mineral can be identified, as well as by the strong pleochroism under the microscope. On one side of the specimen (the left hand of fig. 2), however, the crust consists of rounded grains of a soft, pale apple-green mineral, associated with some pink calcite. From the low specific gravity of the crystal ($G=2{\cdot}6$ about) it was evident that very little, if any, of the original corundum remained unaltered in the interior, and the specimen was accordingly

sawn in half at right angles to the prism; it was found that the tourmaline forms a thin outer shell (except on one face, as noted above) whose thickness is very uniform and seldom exceeds 1^{mm}, and that no visible trace of the original corundum exists. The interior is filled with a pale green material, having a greasy feel and a hardness between 2 and 3, which is, in fact, identical with that which forms the outer surface on one side of the crystal; dispersed through this are a few patches of white to pink calcite, and numerous minute scales of pennine and of a silvery white mica (damourite); there are also one or two small patches of the granular black tourmaline. For the most part, the green material appears quite compact on the smooth surfaces obtained by cutting through the crystal, but on a broken surface it has a more definite prismatic structure, with a pair of fair cleavages inclined at about 90°. The cleavage angle of these prisms could only be determined approximately by maximum illumination measurements owing to its irregularity and the dull lustre. Thin flakes are translucent but exhibit no definite optical characters under the microscope. The specific gravity is about 2·6 and the streak white. The mineral fuses easily and quickly in the Bunsen flame to a white glass, and gives off water when heated in a closed tube; it is insoluble in acids. Owing to the intimate mixture with calcite, and especially to the presence of the small pennine and damourite flakes, it is difficult to select a pure sample for analysis, and the material used may possibly have contained small amounts of these minerals. A single analysis gave the following:

SiO_2	43·05
Al_2O_3	30·28
Fe_2O_3	3·30
MnO	0·49
CaO	1·85
MgO	6·70
K_2O	3·68
Na_2O	0·92
Ignition	10·70
	100·97

The above analysis serves at least to show the approximate composition of the pale green material which constitutes the main portion of the interior of the crystal, so far as can be judged from the surface exposed by sawing through the specimen. This appears to be a mineral of indefinite composition belonging to the pinite group. In view of its (probable) rectangular cleavages, it may be noted that this mineral

approaches in chemical composition to wilsonite and other pseudomorphs after scapolite, which it further resembles in having a low fusibility and a density of about 2·6; indicating that the pinite may here also be an alteration product of scapolite. The presence of calcite dispersed in patches throughout the mass would be well in accord with such a replacement.

It would seem, then, that the original crystal of corundum was first coated with a thin layer of granular black tourmaline; that the corundum kernel subsequently underwent a pseudomorphous change to some mineral having cleavages at 90° or nearly 90,° such as scapolite, and that this in turn became altered to pinite. I have not, however, been able to find any description of, or reference to, pseudomorphs of scapolite after corundum.

The exact locality of the specimen is not known, but it comes from the apatite region of Perth, Ontario, and it is interesting that a cavity in one of the prism faces contains a little transparent apatite of a pale greenish yellow color.

The pseudomorph is especially remarkable on account of the size, and the sharp outline and regularity of the crystal, in which respects it differs much from the majority of corundum crystals from Canadian localities, these being usually much smaller and not so well developed.

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ART. IX.—*The Estacado Aërolite;* Description by KENNETH S. HOWARD; Analysis by JOHN M. DAVISON.

I

THE aërolite from Texas recently obtained by Ward's Natural Science Establishment, as noted in the February issue of this Journal, has been brought to Rochester, sliced, and analyzed chemically and petrographically.

What is known concerning the fall of this meteorite is told by a resident of Hale Center, Texas: "The best history I can give of the meteorite is as follows: It was found twelve miles south of Hale Center, which is located in the center of Hale County, Texas, in the spring of 1902, or rather that is when it was taken home by R. A. McWhorter, who has been the owner of it all the time. In the year of 1882 a bright meteor was seen one night by the people of a Quaker colony called Estacado. This place is about fifteen miles southeast of where the meteor was found. The meteor was seen to pass to the west and fall northwest from them. At that time this Quaker colony was the only settlement on the whole Staked Plains, and the only people outside of them were a few scattering cowmen. In the following year of 1883 a few cowboys, in rounding up the range, saw this meteor and the Estacado people felt certain that this was what they saw fall the year before, and we have all considered it so." As the region is a stoneless one, the attention of the people of the vicinity were naturally attracted to this remarkable mass. The name of the settlement, Estacado, seems most appropriate for the aërolite.

The weight of the meteorite before sawing was about two hundred ninety kilograms, it thus being among the largest of known aërolites. Its form was trapezoidal, as shown by the photographs. Its longest diameter was $58{\cdot}5^{cm}$, while its other two diameters measured $45{\cdot}7^{cm}$ and $44{\cdot}4^{cm}$. It was cut in half parallel to its longest and shortest diameters. Several slabs were taken off at the same time, one of them being shown in photograph 3. The greatest vertical diameter of this slab is about 18^{cm} back of what was apparently the "nose" of the meteorite.

The exterior of the mass is rusty brown in color, probably due to terrestrial oxidation. The sawed slices of the stone show a tendency to rust rapidly. Hardly any of the coating of the meteorite approaches in appearance the black of an original crust. On some of the sides the oxidation has been considerable, a scale knocked off of one side being 3 to 4^{mm} thick. As shown by the photographs (figs. 1, 2), the mass has

FIGURE 1.

FIGURE 2.
The Estacado Aërolite.

eight well-marked sides, one of which (F in photograph 3) looks like an old fracture surface. The oxidation on this side is less than elsewhere and there is no apparent variation in structure as the edge is approached, such as there is on the other sides. The sides are quite flat, some of them even slightly concave, the edges between adjoining sides being, for an aërolite, fairly angular.

Side A has a smoothed appearance and may have been the "nose" of the mass in flight. The surface markings on this

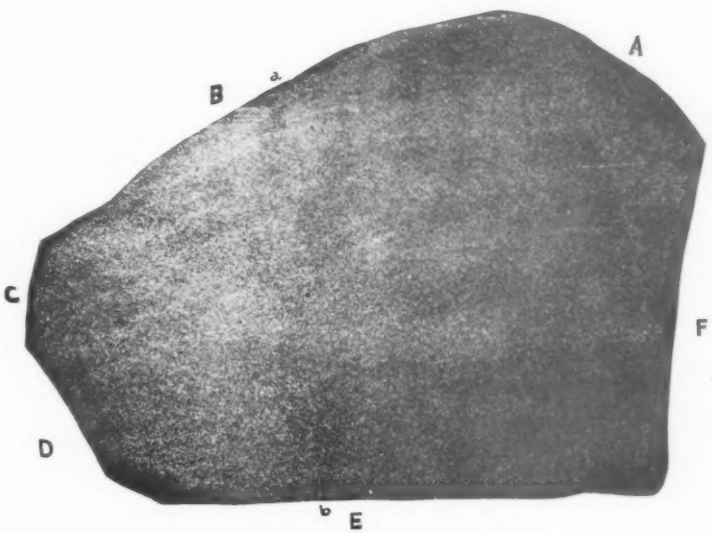


FIGURE 3. Longitudinal slice of Aërolite.

side are not deep, while on sides D and E, which are opposite A, there are well defined pittings.

The stone is a crystalline chondrite, its structure being very similar to the Pipe Creek aërolite, which is also from Texas. In Brezina's classification Pipe Creek is placed in group Cka.

The slab shown in the photograph is 53·4^{cm} in length and 40·6^{cm} in height. The polished surface shows a dull black ground mass thickly permeated with irregular particles of nickel iron. Roundish enstatite chondrules of a more shiny black are scattered through the stone. Here and there are green olivine chondrules, some of which are larger than any of the black chondrules. The largest of the green ones, which is in the center of the slice shown in the photograph (fig. 3), measures about 1^{cm} in length.

The slice also shows some other interesting markings. Some five centimeters from the center toward the smaller end a straight dark line (ab) runs across the meteorite at an inclination of about 15° from the vertical. It passes just to one side of one of the olivine chondrules shown in the photograph. Parallel to, and 15^{cm} from, side A is an irregular and somewhat broken line composed of the metallic particles. This line runs from the edge of side F nearly to the edge of side B.

The line also shows on some of the other slabs, and on one of them, just before it reaches the edge of side B, it turns and runs parallel with the edge for a couple of centimeters. On the various slabs the metallic lines are at different distances

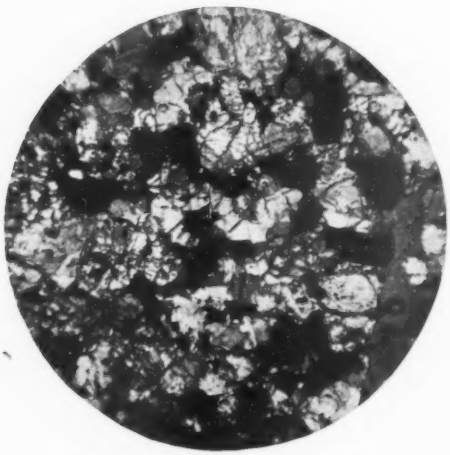


FIGURE 4. Micro-section. ×40.

from side A, indicating that a seam of this material passes through the meteorite obliquely to the cut surface. From the edge of side F, which shows comparatively slight oxidation, three indistinct veins run into the meteorite. They are black, indefinite in outline, and somewhat branching.

A petrological analysis by W. Harold Tomlinson of Germantown, Pa. shows that the mineral constituents are olivine and enstatite. Some pyrrhotite was also found. Mr. Tomlinson remarks: "The olivine and enstatite occur both as grains and as chondri. The grains of olivine contain frequent inclusions of smaller grains and of iron, and occasionally have gase-

ous inclusions. The inclusions in the enstatite are generally parallel to the cleavage." He found the specific gravity to be 3·60. The microphotograph (fig. 4) was made between cross nicol prisms, the magnification being about forty diameters.

II

Chemical Analysis by John M. Davison.

The specific gravity of the Estacado aërolite is 3·63. The metallic part was separated with a magnet, and the slight amount of adhering stony matter determined and deducted.

The stony part was separated by hydrochloric acid into a soluble and an insoluble portion. The insoluble portion was digested with a solution of Na_2CO_3 and the dissolved SiO_2 added to that dissolved by HCl. This analysis gave

Metallic		16·41 per cent.
Stony	Soluble in HCl	41·09 "
	Insoluble in HCl	42·50 "
		100

Analyses of these, omitting minor constituents and calculated to 100, gave

Metallic.		Soluble in HCl.		Insoluble in HCl.	
Fe	89·45	SiO_2	32·00	SiO_2	63·57
Ni	9·99	MgO	32·02	MgO	23·45
Co	0·56	FeO	31·60	FeO	9·54
		CaO	4·38	CaO	3·44
	100		100		100

The stony part appears to be mainly olivine and enstatite. The analysis of the entire mass gave the following percentages:

Fe	14·68	Al_2O_3	3·60
Ni	1·60	Na_2O	2·07
Co	0·08	K_2O	0·32
Cu	trace	TiO_2 found but not determined	
C found but not determined		Cr_2O_3 " " " "	
S	1·37	MnO " " " "	
P	0·15		100·95
SiO_2	35·82	Less O for S	·68
FeO	15·53		100·27
MgO	22·74		
CaO	2·99		

Of the S found 0·82 per cent came from the metallic and the portion soluble in HCl, and 0·55 per cent from the insoluble portion fused with Na_2CO_3. In this fusion the crucible was screened by a close fitting asbestos board, and a blank experiment showed that there was no contamination from the gas flame. This distribution of the S would indicate that nearly half of the troilite was embedded in the enstatite protected from action of acids.

From 3·9597 grams of the aërolite 0·025 gm. of chromite was separated by repeated treatment with HFl and other acids. With the chromite were a few minute particles of a transparent colorless mineral that had survived this usage, though evidently attacked.

Search was made for ZrO_2, with negative result.

ART. X.—*On Stibiotantalite;* by S. L. PENFIELD and W. E. FORD.

Historical.—Stibiotantalite was first described by G. A. Goyder* in 1892 and more minutely in 1893, as occurring in rounded water-worn fragments in the tin-bearing sands of Greenbushes, West Australia. No crystals were observed, but it was evident from the cleavage of the material and its action on polarized light that it possessed a crystalline structure, and it was assumed that it belonged to the orthorhombic system, though no convincing evidence was brought forth. An analysis, which is quoted later in this article, indicated that the mineral is essentially a combination of oxides of antimony and tantalum, with some niobium and a very little bismuth, but no formula was suggested. The physical properties were given as follows:—Hardness, 5 to 5·5. Specific gravity, 7·37. Luster, adamantine to resinous. Color, pale reddish-yellow to greenish-yellow. Fracture, subconchoidal to granular. Within the past few years a considerable quantity of this material has become available to collectors through the agency of several mineral dealers.

Crystals from Mesa Grande, San Diego County, California, a New Locality.

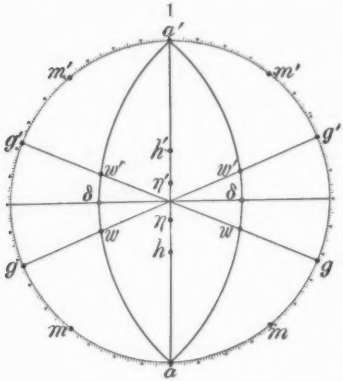
The material from Mesa Grande was brought to the attention of the present writers by Mr. Ernest Schernikow of New York. It was observed by him as occurring very sparingly with the wonderful tourmaline crystals found at the locality and described by Sterrett,† and great pains were taken to have every crystal and fragment carefully saved. In all, some twenty-five crystals have been found, representing several years savings from a vast amount of material, so it may be considered a rare mineral at the locality. Associated with it, besides the tourmaline already referred to, are large and wonderfully beautiful crystals of pink beryl of unusual habit, fine crystals of quartz, orthoclase and lepidolite, and, as a great rarity, cassiterite. The orthoclase is generally kaolinized to a considerable extent. Several crystals of stibiotantalite were observed grown on to, or over, pink tourmaline; one group has attached to it a little feldspar and lepidolite; the others are all detached crystals and some of them are doubly terminated. None of the detached crystals show fresh fractures, and they evidently were found loose in the deposit. Stibiotantalite appears to be

* Proceedings Chem. Soc., 1892, 9, p. 184. Journal Chem. Soc., 1893, lxiii, p. 1076.

† This Journal (4), xvii, p. 459, 1904.

of later origin than the tourmaline and lepidolite, though undoubtedly it was one of the primary minerals of the deposit.

The crystals are mostly of a rich dark-brown color, with resinous to adamantine luster. Fragments look exactly like the resinous variety of sphalerite, and a few pieces were found of light brown color, transparent, and so closely resembling the well known sphalerite from Picos de Europa, Spain, that by appearances the two can not be told apart.



Stibiotantalite crystallizes in the orthorhombic system and is hemimorphic. With few exceptions, the habit of the crystals gives no suggestion of hemimorphic development, which, according to the orientation adopted, is in the direction of the brachy- or *a*-axis. All the crystals that have been studied are polysynthetic twins, thus causing them to imitate the symmetry of the normal group. In habit they resemble columbite, and, as will be shown, the two minerals are related both in chemical composition and axial ratio. In order to bring out the crystallographic relationship, however, it has been necessary to assign rather complex symbols to some of the forms of stibiotantalite, but it is believed that it is better to do so than to give simpler symbols to the forms and refer them to other axes. The axial ratio of the two minerals are as follows:

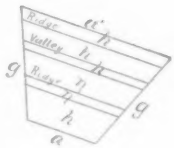
Stibiotantalite ..... $a : b : c = 0{\cdot}7995 : 1 : 0{\cdot}8448$
Columbite ..... $a : b : c = 0{\cdot}8285 : 1 : 0{\cdot}8897$

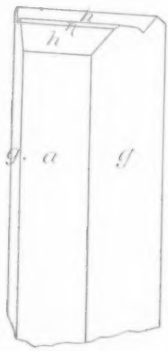
The forms observed on stibiotantalite are shown in stereographic projection in figure 1, but, owing to polysynthetic twinning, it is impossible to state as regards some of them whether they occur both in front and behind, or intersect only one end of the brachy-axis, as demanded by hemimorphism. The symbols are as follows:

a (100)	η (209)
a' ($\bar{1}$00)	η' ($\bar{2}$09),
m (110) or ($\bar{1}$10)?	h (203), probably also h' ($\bar{2}$03)
q (130)	δ (043)
q' ($\bar{1}$30)	w (4·12·9) probably also w' ($\bar{4}$·12·9)

The only crystals observed which exhibit a marked hemimorphic development are represented in figures 2, 3 and 4. They are orientated according to pyroelectric deportment, the *a* faces to the front all developing negative electricity on cooling, as tested by the carmine-sulphur-lycopodium mixture suggested by Bürker.* The crystal shown by figure 2 has at the top two ridges and a valley, but no reëntrant angle at the sides: The two ridges on cooling develop positive, and the valley negative electricity. This crystal is a polysynthetic twin, and may be taken as a type for illustrating the structure of other crystals. The vertical axis is the twinning axis, and the macropinacoid *a* the composition face. If it is assumed as in figure 5 that a hemimorphic crystal has the prism *g* (130) and the dome η (209) intersecting the front end of the *a*-axis only, a lamella in twin position, figure 6 (as indicated by the letters underlined), would give a ridge and a valley at the top, corresponding to figure 2, but also reëntrant angles at the sides, which do not occur on the crystal shown in figure 2. It seems therefore necessary to assume that, in addition to *g* to the front, there is a corresponding g' ($\bar{1}30$) behind and, as will be shown, also, an η' ($\bar{2}09$) behind, figure 7: These forms appear in twin position as shown in figure 8, and an interspersed twin lamella, as in figure 9, may then show at the sides the prism g' corresponding in direction with *g*. The prism lettered *g*, figure 2, is therefore to be regarded as a composite face, composed partly of *g* and partly of g'. At the top of such a crystal there may be, as in figures 2 and 9, a ridge and a valley, provided that in the twin lamella there occurs in connection with g' not η' sloping to the front but η sloping behind. As a matter of fact, only a few of the crystals

2



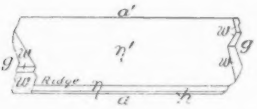


*Annalen der Physik, 1900, I, p. 474. *Note.* Bürker states that with this mixture carmine goes to positively electrified surfaces and sulphur plus lycopodium to negative, which seems contrary to reason, for sulphur should become strongly negatively electrified by agitation and go to a positively electrified surface, the same as with the method of dusting with red oxide of lead and sulphur. As a matter of fact, sulphur does go to the positively electrified pole, but each grain, as may be seen with the microscope, is loaded with a fine dust of carmine and gives a red effect. The lycopodium, on the other hand, goes to the positive pole, and is very free from any admixture of either carmine or sulphur, hence it gives with the sulphur-carmine mixture a strong and sharp contrast of color.

show reentrant angles at the top, and the faces of later figures lettered η or η' must in reality be regarded as composite, made up partly of η and partly of η'.

Figures 3 and 4 both show hemimorphic character by the development of η' behind, but this face is in reality composite, composed in part of η in twin position. Figure 3 shows prominent reentrant angles at the sides, compare figure 6: none of the other crystals show these so prominently,

3



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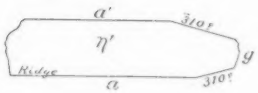
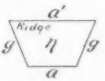


and as a rule reentrant angles are so small as to give the effect of fine striations parallel to the vertical axis, or a rounding of the obtuse edge between g and g', as if resulting from oscillatory combination, figure 4. The crystal represented by figure 4 is the only one showing any prominent development of a replacement of the edges between a and g; the form, however, is so striated and distorted by the development of vicinal faces that no satisfactory measurements could be obtained; it approximates to (301) respectively ($\bar{3}01$), but the symbols are

5



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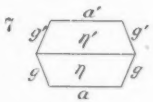

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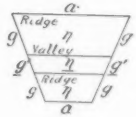

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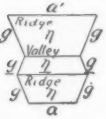

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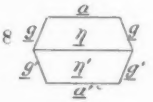
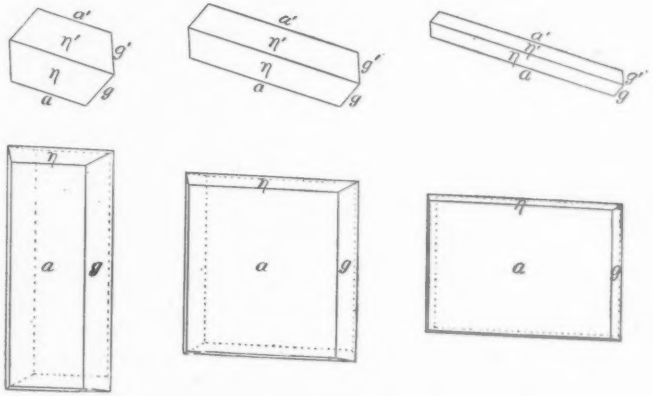


questionable. The pyramid w is developed to so slight an extent and the crystals are so complicated by polysynthetic twinning that it is impossible to state whether it occurs only in front or only behind; hence it is assumed that both forms, w (4.12.9) and w' ($\bar{4}$.12.9), are present. With the exception of the three crystals just described, the general habit is like that of the normal group of the orthorhombic system, as illustrated by figures 10 to 13, in which the forms are represented with ideal symmetry, whereas they all show vertical striations on the pinacoid and prism faces, and some rounding of the edges between g and g'. One crystal only, figure 12, is shorter in

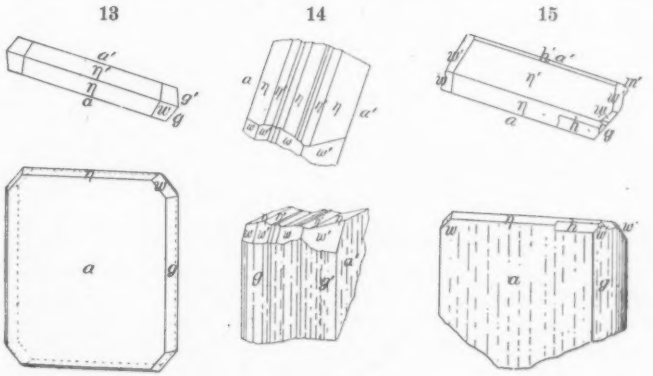
the vertical than the horizontal direction. The largest crystal of the types illustrated is shown in about natural size in figure 13, which measured in the direction of the a, b and c axes, respectively, $6 \times 25 \times 30^{mm}$, while the remaining ones average

10 11 12



about one-fourth this size. Figure 14 shows in detail one of the corners of the crystal idealized in figure 13; it is rather unusual in showing the η and η', and w and w' faces with

13 14 15



numerous reentrant and salient angles, while the g and g' faces are finely striated and round into one-another. At the opposite end of the crystal the η and w faces appear without reentrant angles.

The general resemblance to columbite is shown by the prominent development on both species of the macropinacoid a, parallel to which stibiotantalite has a highly perfect and columbite a distinct cleavage, while both minerals have an indistinct cleavage parallel to the brachypinacoid b (010). The prism g is always present on stibiotantalite, while on columbite it is seldom wanting and often prominent. The macrodome h occurs on both minerals but is not common, while the prominent development of rather flat macrodomes, η (209) on stibiotantalite, and k (103) and l (106), respectively (206) and (2.0.12), on columbite is a feature common to both species. The pyramid w (4.12.9), although not occurring on columbite, is in the same vertical zone as two of its prominent pyramids, s (263) and u (133), respectively, (4.12.6) and (4.12.12). If the crystals of stibiotantalite were black and of metallic luster they certainly might be mistaken for columbite, because of similarity in appearance, habit, occurrence and association. Columbite, it should be stated, is not hemimorphic and does not exhibit pyroelectricity.

Crystals of stibiotantalite show certain peculiarities as regards the development of the forms and the character of the surfaces, as follows:—

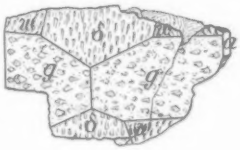
The macropinacoids a and a', which are generally the most prominent of all the forms, have a bright luster and are usually striated vertically, the striæ being rather fine and seldom giving rise to much rounding or irregularity of the surface: on a few crystals they appear almost free from striations. Both (100) and ($\bar{1}$00) occur without any apparent difference, except when tested for pyroelectricity, and then it generally appears that the same surface develops two kinds of electricity owing to twinning and interpenetration.

The prisms g (130) and g' ($\bar{1}$30) are present on all of the crystals and are always striated vertically, due to polysynthetic twinning and in part perhaps to oscillatory combination, both causes giving rise to a rounding of the edge between g and g', or as is frequently the case, to a considerable distortion when one prism face predominates over the other, figure 14. In almost all of the crystals, however, portions of the prismatic faces are quite free from striations, so that good measurements may be had. Any modification of the edge between a and g was rarely observed. On two crystals distinct replacements, indicating the presence of a prism corresponding to m (110) or m' ($\bar{1}$10) were noted, but the faces were too poorly developed to give good measurements; compare figure 15.

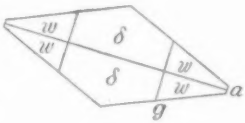
The macrodomes η (209) and η' ($\bar{2}$09) are prominent on all of the crystals as shown by the figures. A single face is generally composed of both η and n' as explained on page 58.

The domes are generally free from striations and dull in comparison with the other faces, appearing as if corroded, but on a few of the crystals they are bright and somewhat striated, not sufficiently so, however, to interfere with measurements. The domes h (203) and perhaps h' ($\bar{2}03$) occur on only a few of the crystals, two of which are shown as nearly as possible in true proportions in figures 2 and 15. On both crystals the surfaces were so dull, seemingly etched, that on the goniometer they gave no reflections of the signal, but by placing bits of microscopic cover glass against the faces satisfactory measurements were obtained which leave no doubt as to the correctness of the symbol. Owing to the interposition of a twin lamella, the dome h, in front, shown in figure 15, extends only about one-third way across the crystal.

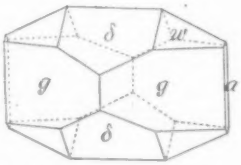
16



17



The pyramid w (4.12.9) appears on only a few of the crystals, is never very prominent and its development is so complicated by polysynthetic twinning, that it is difficult to state whether it occurs in front (4.12.9), or behind ($\bar{4}$.12.9), or in both positions. The pyramid faces are often striated parallel to the edge $4.12.9 \wedge \bar{4}.12.9$, as if in oscillatory combination, and frequently distinct reentrant angles occur, figures 3, 14, and 15, which indicate rather that the striations result, in part at least, from polysynthetic twinning. The pyramid faces generally have bright surfaces which yield good reflections even when the accompanying dome faces are dull.



A basal plane c and brachypinacoid b have not been observed, but occasionally owing to oscillatory combinations of $g \wedge g'$, or as a result of polysynthetic twinning, a striated surface results, approximating in position to b.

The surfaces as a whole are not the best for reflecting light, and striations gave rise to further difficulties, but it is believed that the measurements and axial ratios derived therefrom must be very nearly correct.

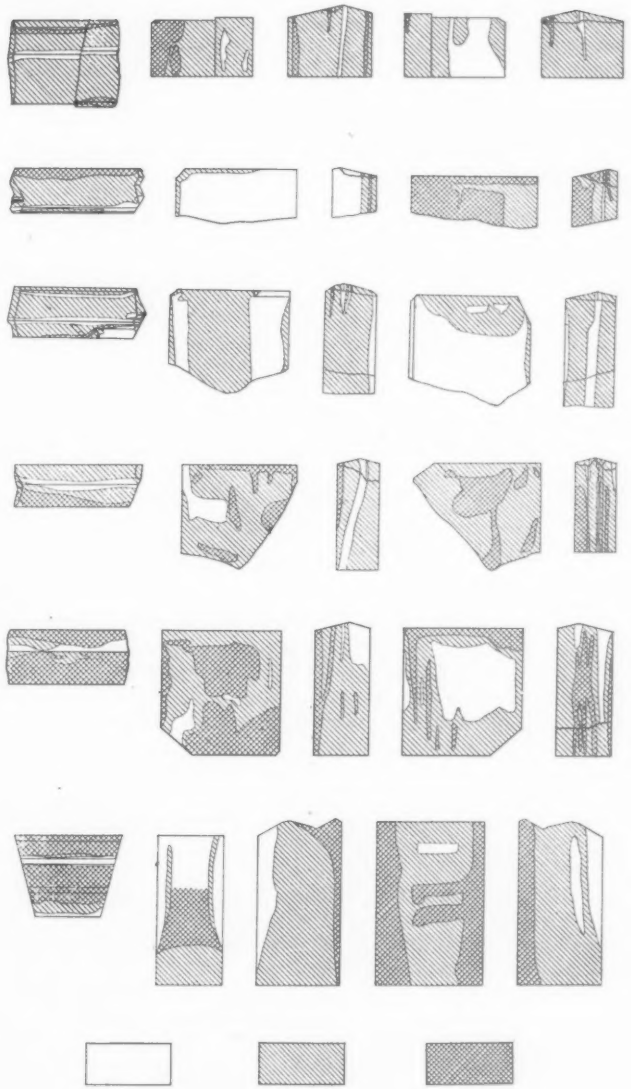
The crystal shown in figure 16, considerable portions of which are missing, is unique. It measures about 5^{cm} in length, 4 in height and 3 in thickness, respectively in the directions of the a, c and b axes, and weighs 150 grams (over 5 ounces), or

six times as much as the next largest crystal, which is of the type shown by figure 13. It was found at a considerably later period than the other crystals, and at a different part of the deposit. It was picked up in two pieces, and the fracture surfaces do not appear fresh, as if recently broken in taking the crystal from the matrix. Originally it must have been quite symmetrical in development and in shape about as shown in figure 17, which, as is also the case with figure 16, is drawn with the a faces to the right and left, instead of front and back, in order to show the form to best advantage. It was attached at the lower left-hand corner to pink tourmaline, bits of which are still adhering to it. The upper and lower edges, and a considerable portion of the lower, right-hand corner have been broken away. The a, a' faces to the right and left are fresh-looking cleavage surfaces; and whether the pinacoids a and a' were originally present, as shown in figure 17, or whether adjacent g faces came together at the acute edges, cannot be told.

The habit of this crystal is entirely different from that of the others, and the peculiarities of its surface are also different. The brachydome δ (043) has been observed only on this crystal. The prism g is not striated vertically. The surfaces are all etched, so that only measurements with a contact goniometer may be had, but these all agree with those obtained from other crystals. The best-formed etchings on the prism g are rather deep depressions, shaped about as shown in figure 16, though the majority are much more rounded: in places they join one-another, giving rise to furrows running irregularly over the surface. The etchings on the brachydome δ are long depressions, some of them quite deep, while those on the pyramid w are also long, but somewhat comma-shaped, the tails pointing away from the edge $w \wedge \delta$. The crystal is light yellowish-brown in color, more transparent than any of the others, and has a specific gravity of 6·69.

The crystal is a polysynthetic twin, though the outward form gives no evidence of it. The two large fragments which make up the specimen do not of themselves exhibit pyroelectricity, probably because of numerous cracks running through the material, but a small homogeneous fragment, when tested, exhibited alternating bands of positively and negatively excited material, remarkably uniform and not over 2^{mm} in width.

Throughout a portion of its interior the crystal is curiously cavernous, although the exterior is firm and consists of remarkably pure, transparent material. The cavity looks as though it had been eaten out by some solvent, and is lined with some secondary material which without endangering the specimen could not be gotten out in sufficient quantity for a satisfactory



a, negatively electrified areas; *b*, neutral areas; *c*, positively electrified areas.

Plate showing the distribution of negatively electrified, neutral and positively electrified areas of crystals when cooled.

test. Resting on this secondary material are a few very minute pyramids of cassiterite.

Pyroelectricity.—The pyroelectric phenomenon which is exhibited by all of the crystals is a matter of interest. It reveals a complex polysynthetic twinning structure, as the result of which the crystals with few exceptions appear as if they possessed normal orthorhombic symmetry. Each crystal has its own peculiar polysynthetic development, and it seems sufficient to select a few examples as types, in which the distribution of the electrically excited surfaces is indicated diagrammatically, as in the accompanying plate, page 63. The crystals are represented, as it were, unfolded; there is given first a top view, then in turn views of the front, right-hand side, back and left-hand side. Lower ends have not been represented because, with few exceptions, they are fracture surfaces. As stated on page 63, the crystals were tested for pyroelectricity with a mixture of carmine, sulphur and lycopodium, with which negatively and positively electrified surfaces are coated respectively, white by lycopodium, and red by sulphur coated with carmine. In the diagrams the negative surfaces are indicated by white (lycopodium), the positive by cross lines (red, sulphur and carmine), while the neutral, brown surface of the crystals is simply lined. The diagrams illustrate how irregularly the lamellae are intergrown and, to a certain extent, how complex the twinning really is, but they do not do the subject full justice, for often the lamellae are very thin and red and white alternate in bands, too narrow to be represented by line drawings.

Two pebbles of the stibiotantalite from Greenbushes, Australia, belonging to the Brush Collection, were tested for pyroelectricity, but in their entirety gave no effect; when broken up, however, small homogeneous pieces gave the reaction distinctly, and it may be assumed that failure to get a response from the larger pebbles is because of the numerous cracks which permeate the material.

Crystal Measurements.—The measured and calculated angles are as follows:—

				Measured.	Calculated.
$g \wedge g'$, 130	$\wedge$	$\bar{1}30$	=	45° 16′*	
$g \wedge w$, 130	$\wedge$	4.12.9	=	39 20*	
$m \wedge m'''$, 110	$\wedge$	$1\bar{1}0$	=	approximately	77° 18′
$w \wedge w'$ 4.12.9	$\wedge$	$\bar{4}.12.9$	=	34 43	34 38
$w \wedge w'''$, 4.12.9	$\wedge$	$4.\bar{1}\bar{2}.9$	=		91 6
$\eta \wedge \eta$, 209	$\wedge$	$\bar{2}09$	=	26 30	26 26
$a \wedge h$, 100	$\wedge$	203	=	54 30	54 50
$\delta \wedge \delta'$, 043	$\wedge$	$0\bar{4}3$	=	approximately	96 48

From the measurements marked by an asterisk the axial ratio given on page 62 was calculated.

Orthorhombic symmetry was shown by the measurements of $q \wedge w$ in four upper octants of one crystal, which, though varying from 39° 15′ to 39° 25′, are as nearly alike as the character of the reflections warrant. The crystal on which these measurements were made is the one shown in figure 15, where the distribution of the w faces is like that of the normal group of the orthorhombic system, owing perhaps to polysynthetic twinning.

Optical Properties.—Thin sections cut parallel to the three pinacoids, when examined in polarized light, all showed extinction parallel to directions corresponding to the crystallographic axes. Some of the sections were not uniformly colored throughout, some portions being darker than others, but whether this phenomenon is due to any essential variation in chemical composition or not has not been determined. It is believed that if the difference in color indicates any variation in chemical composition, it is probably slight.

The indices of refraction vary somewhat for crystals of different specific gravity. Determinations have been made on two crystals; one having a specific gravity of 6·818, and the other of 6·299. In both cases the indices of refraction were determined from two prisms; one with a face parallel to the base and its edge parallel to the a-axis, which gave with 90° incidence the values for rays vibrating parallel to the a and b axes, respectively, β and $\mathfrak{a}$; the other prism with its edge parallel to the c-axis gave the value γ. The optical orientation is therefore $a=\mathfrak{b}$, $b=\mathfrak{a}$ and $c=\mathfrak{c}$. With basal sections, also, 2H acute was measured in potassium mercuric iodide solution, $n_y=1{\cdot}7156$. The values for the two crystals are as follows:—

Specific gravity 6·818, corresponding to about 39 per cent Ta_2O_5 and 17·5 per cent Nb_2O_5.

	a	β	γ	$2V$, Calculated		$\gamma-a$
For Li	2·3470	2·3750	2·4275	∴ 73°	40′	·0805
" Na	2·3742	2·4039	2·4568	∴ 75	5	·0826
" Tl	2·4014	2·4342	2·4876	∴ 77	38	·0862

" Na .... $2Ha = 119° 10′ \therefore 2V = 75° 58′$

Specific gravity 6·299, corresponding to about 22·5 per cent Ta_2O_5 and 30 per cent Nb_2O_5.

	a	β	γ	$2V$, Calculated		$\gamma-a$
For Li	2·3686	2·3876	2·4280	∴ 70°	0′	·0594
" Na	2·3977	2·4190	2·4588	∴ 73	25	·0611
" Tl	2·4261	2·4508	2·4903	∴ 77	50	·0642

" Na $2Ha = 113° 11′ \therefore 2V = 72° 37′$

As may be seen from the above, the mineral is characterized by an unusually high index of refraction, the values γ for yellow, 2·4568 and 2·4588, being somewhat higher than that of diamond, 2·418, and considerably above that of sphalerite, 2·369, yet so near the latter that, both minerals being of the same color and possessing good cleavage, it is evident that fragments of the two must look exactly alike. An unusually strong dispersion, $\rho < v$, is a marked feature of the mineral, and also a high birefringence, $\gamma - \alpha$ for yellow being for the crystal of higher specific gravity ·0826, and for the other ·0611. The character of the birefringence is positive. The plane of the optical axes is the macropinacoid (100), and the vertical axis c is the acute bisectrix.

The divergence of the optical axes, $2V$, is so great that $2E$ can not be observed; in fact, the mean index of refraction of the mineral is so far above that of our highest refractive liquids that it was with the greatest difficulty that $2H$ could be observed: This was due in part to the fact that the sections, prepared from the same crystals from which the prisms were cut, contained some dark inclusions which interfered with the transmission of light. $2H$ therefore was measured only for sodium light, the illumination from lithium and thallium flames being too weak to yield distinct interference figures. It seems rather anomalous to have $2H$ acute as high as 119° and 113°, but this is due to the very high index of refraction of the mineral. In both crystals the agreement between the values of $2V$, as calculated from the three indices of refraction and from $2Ha$, are as satisfactory as could be expected, considering the difficulties encountered in preparing the prisms and sections, and making the measurements. As shown by the tabulated results, the substitution of Nb_2O_5 for Ta_2O_5 causes a slight increase in the values of the indices of refraction, a decrease in birefringence $(\gamma - \alpha)$ and, except in the case of thallium, a decrease in $2V$. The dispersion is much more marked in the crystal of lower specific gravity, the differences of $2V$ for green and red being in the one about 4° and in the other about 7°.

Chemical Composition.—For chemical analysis two crystals were employed, one having a specific gravity of 6·72, and the other 5·98. The method of analysis was as follows: The mineral was dissolved, without heating, in hydrofluoric acid in a platinum dish, and the antimony and bismuth precipitated by hydrogen sulphide. The precipitate was collected on a filter and then digested with a solution of sodium sulphide in order to separate antimony from bismuth. The undissolved bismuth sulphide was collected, dissolved in warm nitric acid and, after removal of the latter, reprecipitated by hydrogen sulphide. The precipitate was then collected on asbestos,

ignited in a current of carbon dioxide and weighed as Bi_2S_3. The antimony separated from the bismuth was reprecipitated as sulphide, collected on asbestos, and, after heating in carbon dioxide, weighed as Sb_2S_3. Preliminary experiments with known amounts of bismuth and antimony proved that the methods as given above yielded correct results. The filtrate from the original sulphide precipitate, containing the niobium and tantalum, was evaporated to dryness and the residue decomposed by fusion with acid potassium sulphate. The fusion was then digested with water and the insoluble niobium and tantalum oxides were filtered, ignited and weighed. Qualitative tests indicated that there were not determinable quantities of other substances present. The results of the analysis of the original stibiotantalite from Australia by Goyder, together with those of two varieties of the mineral from Mesa Grande, are as follows :—

	Australia.	Mesa Grande.			Mesa Grande.		
Specific gravity	7·37	6·72			5·98		
		I	II	Average	I	II	Average
$(Ta,Nb)_2O_5$	58·69	55·22	55·44	55·33	50·57	50·03	50·30
Sb_2O_3	40·23	44·31	44·21	44·26	49·07	49·49	49·28
Bi_2O_3	·82	·31	·34	·33	·53	·54	·53
				99·92			100·11
NiO	·08						
H_2O	·08						
	99·90						

The results of the analyses indicate that with decrease in specific gravity there is an increase in antimony oxide, and a proportional decrease in the combined acid oxides, due to the isomorphous replacement of heavier Ta_2O_5 by lighter Nb_2O_5. As there is no satisfactory method for separating tantalum from niobium, the attempt has been made to determine the proportions of the two oxides by taking the specific gravity of the mixed oxides as obtained from the analyses, and comparing the results with those of pure Ta_2O_5 and Nb_2O_5, which are quite widely separated. This method has been tested sufficiently to indicate that it gives fairly satisfactory results, and from the values given below and a consideration of the ratios, which in both analyses are almost exactly 1 : 1, it may be seen that the percentage of the Ta_2O_5 and Nb_2O_5 must be reasonably exact:—

Sp. gr. = 6·72.		Ratio.			Sp. gr. = 5·98.		Ratio.	
Ta_2O_5	36·35	·0815	·1523	1·00	11·16	·0250	·1710	1·00
Nb_2O_5	18·98	·0708			39·14	·1460		
Sb_2O_3	44·26	·1536	·1543	1·01	49·28	·1711	·1722	1·01
Bi_2O_3	·33	·0007			·53	·0011		
	99·92				100·11			

Goyder, in his analysis of the original stibiotantalite from Australia, made no separation of the tantalum and niobium oxides, but assuming that the ratio of $(Ta,Nb)_2O_5 : (Sb,Bi)_2O_3 = 1 : 1$, the proportions of Ta_2O_5 and Nb_2O_5 were determined indirectly. Thus, considering the first of our analyses, where the per cent of $(Ta,Nb)_2O_5$ is 55·33; the per cent of Ta_2O_5 may be taken as x, when that of Nb_2O_5 will be $55{\cdot}33-x$: now having the molecular weights, $Ta_2O_5 = 446$, $Nb_2O_5 = 268$, $Sb_2O_3 = 288{\cdot}4$ and $Bi_2O_3 = 465$, the following equation results:

$$\frac{x}{446} + \frac{55{\cdot}33-x}{268} = \frac{44{\cdot}26}{288{\cdot}4} + \frac{0{\cdot}33}{465}, \text{ from which } x = 35{\cdot}15.$$

Treating all three analyses in like manner, the results, together with the theoretical composition of the end products, are as follows:

	Theory for $(SbO)_2Ta_2O_6$				Theory for $(SbO)_2Nb_2O_6$
Sp. gr.	7·90	7·37	6·72	5·98	5·73
Ta_2O_5	60·73	51·13 (52·16)*	35·15	10·60	0·00
Nb_2O_5	0·00	7·56 (6·53)	20·18	39·70	48·17
Sb_2O_3	39·27	40·23	44·26	49·28	51·83
Bi_2O_3	----	0·82	·33	·53	----
NiO	----	0·08	----	----	----
H_2O	----	0·08	----	----	----
	100·00	99·90	99·92	100·11	100·00

The results of the indirect determination of Ta_2O_5 and Nb_2O_5 in the last two analyses show a very satisfactory agreement with the values derived from the specific gravities of the oxides, and it may be pointed out that a slight variation in the per cent of Sb_2O_3 causes about four times as great a variation in the percentages of Ta_2O_5 and Nb_2O_5, while, also, variations up to 4 per cent in Ta_2O_5 or Nb_2O_5 have little effect upon the ratio owing to the large molecular weights of the acid oxides.

The ratios in the two new analyses, being almost exactly 1 : 1, indicate that in chemical composition stibiotantalite is an isomorphous mixture of $Sb_2O_3.Ta_2O_5$ and $Sb_2O_3.Nb_2O_5$, with a little bismuth replacing the antimony. It is a curious and interesting fact that, in materials from such widely separated localities, the amounts of bismuth should be so nearly alike.

The chemical relation between stibiotantalite and columbite may perhaps be represented best by developed formulas, as follows:

$$O=Sb-O-Nb=O \qquad Fe \begin{cases} O-Nb=O \\ O \\ O-Nb=O \end{cases}$$
$$O=Sb-O-Nb=O$$

* The percentages given in parentheses result from the molecular weights made use of in this article. The figures given by Goyder vary somewhat because he used slightly different molecular weights.

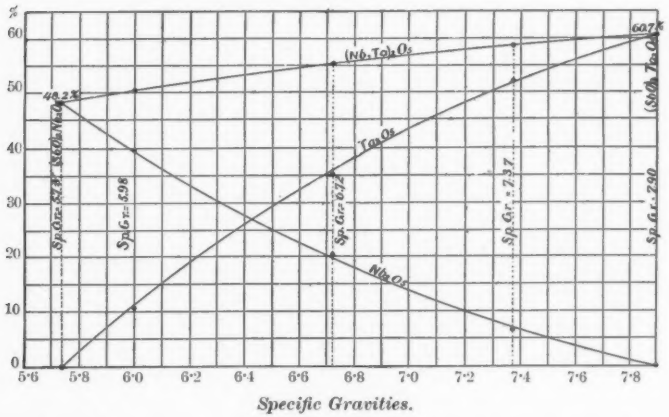
What it is desired especially to bring out by the formulas is that in stibiotantalite two univalent *antimonyl* radicals (O=Sb) play the same rôle as a bivalent atom of Fe in columbite, hence, chemically, the mineral is regarded as a basic antimony tantalate, respectively, niobate. Following ordinary methods, the formulas would be written $(SbO)_2(Ta,Nb)_2O_6$ and $Fe(Ta,Nb)_2O_6$. It may be that the similarities in habit, cleavage and axial ratios between stibiotantalite and columbite, as pointed out earlier in this paper, are mere matters of accident, but, taken in connection with the chemical formulas, this does not seem at all probable. It is assumed that the antimony-oxide radical, known in chemistry as *antimonyl*, plays the part of a metal in stibiotantalite, replacing the hydrogen atoms of tantalic, respectively, niobic acid. This tendency may be noted in a number of compounds of the antimony-bismuth group, where we have basic salts containing the *antimonyl* (SbO) and *bismuthyl* (BiO) radicals. If the crystallographic relationship to columbite is disregarded, the formula of stibiotantalite may be simplified to $(SbO)(Ta,Nb)O_3$, or, looked at in another way, to $Sb(Ta,Nb)O_4$, the latter an antimony salt of normal tantalic, respectively, niobic acid. Against the latter assumption, however, it may be argued that normal salts of tantalic and niobic acid are almost unknown, and the tendency to form a basic salt containing the antimonyl radical would probably be greater than to form an antimony salt of the normal acids. Among minerals which are normal salts of tantalic and niobic acids, there are only two closely related species, fergusonite and sipylite, $(Y,Er,Ce)(Ta,Nb)O_4$ and $Er(Ta,Nb)O_4$, but these may as well be written as basic salts, for example, $(ErO)_2(Ta,Nb)_2O_6$, conforming to the columbite type of formula.

That the antimony in stibiotantalite is trivalent and not pentavalent is known by the summation of the analyses and also by the results of the following experiment:—Some powdered mineral was dissolved in hydrofluoric acid, and the precipitate thrown down by hydrogen sulphide was collected, dried and tested by heating in a closed tube. Had the antimony been pentavalent, the precipitate would have been either Sb_2S_5 or a mixture of Sb_2S_3 and sulphur, and have yielded an abundant sublimate of sulphur when tested in a closed tube; it gave, however, only a trace of sulphur, the same as stibnite, Sb_2S_3, when similarly heated.

By means of the data given in connection with the three analyses which have been made, it is possible to represent the relations between the specific gravity and chemical composition of stibiotantalite graphically, as shown in figure 18, where the specific gravities are taken as abscissas and per cents as

ordinates. Referring to page 73, the percentages of the total acid oxides, $(Nb,Ta)_2O_5$, of the three analyses have been plotted on the vertical lines corresponding to the specific gravities. The three points thus found do not fall quite on a straight line, hence a circular arc is drawn through them and continued. As given on page 74, the theoretical percentages of Nb_2O_5 and Ta_2O_5 in $(SbO)_2Nb_2O_6$ and $(SbO)_2Ta_2O_6$ are, respectively, 48·2 and 60·7; hence where the $(Nb,Ta)_2O_5$ curve intersects, horizontal lines corresponding to the above figures must determine approximately the specific gravities of the two unknown end products, namely 5·73 and 7·90. Next, the percentages of Nb_2O_5 and Ta_2O_5, as given on page 74, were plotted, and, as shown by the figure, these fall very near two circular arcs, one

18



Specific Gravities.

passing from 0 per cent to 48·2 per cent Nb_2O_5, the other from 0 per cent to 60·7 per cent Ta_2O_5. The greatest variation of the determinations of Nb_2O_5 and Ta_2O_5 from these curves is not over one per cent, which is well within the errors of analysis. If instead of using the values for Nb_2O_5 and Ta_2O_5 given on page 74, which were obtained indirectly from the percentages of Sb_2O_3 and Bi_2O_3 and were selected because the three analyses received like treatment, the values as given for our two analyses on page 73 are plotted on figure 18, the points fall almost exactly on the Nb_2O_5 and Ta_2O_5 curves. Certainly, considering the difficulties of the analyses, the close conformity of the determinations to the two curves is a most satisfactory confirmation of the reliability of the results obtained. It was by means of the diagram that the approximate composition of the two crystals studied optically, as

given on page 71, was determined. The majority of the crystals examined range in specific gravity from 6·6 to 6·7.

Pyrognostics.—Stibiotantalite, when heated intensely at the tip of the blue flame, is fusible at about 4 and imparts a pale bluish-green color to the flame due to volatilization of antimony. After driving off a part of the antimony there is left an infusible mass of niobium and tantalum oxides generally darkened by antimony. If the flame from the mineral is directed against a piece of charcoal a considerable coating of oxide of antimony collects on the coal.* When fused with 3 or 4 times its volume of sodium carbonate on charcoal, a coating of antimony oxides and small globules of metallic antimony are obtained. The powdered mineral is not appreciably attacked by ordinary acids, not even by boiling, concentrated sulphuric, but is readily soluble in hydrofluoric acid. Unchanged when heated in closed and open tubes and gives no characteristic reactions with the fluxes.

Summary.—Stibiotantalite is a mineral first found in rounded, water-worn pebbles in Australia and recently in well-crystallized specimens in California. In chemical composition it is an isomorphous mixture of $(SbO)_2Nb_2O_6$ and $(SbO)_2Ta_2O_6$, exhibiting a wide range in specific gravity, from 5·98 to 7·37, depending upon the proportions of Nb_2O_5 and Ta_2O_5 present. The crystals belong to the hemimorphic group of the othorhombic system, although, owing to twinning, they imitate the symmetry of the normal group. In axial ratio, development and occurrence of several forms, the mineral is related to columbite. Stibiotantalite is characterized by an unusually high index of refraction, above diamond, a high birefringence and a wonderful luster.

In closing, the writers take special pleasure in expressing their thanks to Mr. Ernest Schernikow, of New York, who has most generously placed at their disposal for study all of the crystals which the locality, so far as known, has afforded. He may well be proud that his eagerness to promote the science of mineralogy has enabled him to bring to light a mineral of such unusual beauty and scientific interest.

Mineralogical Laboratory of the
Sheffield Scientific School of Yale University,
New Haven, Conn., February, 1906.

*Tried in the same way as when testing for zinc; Brush-Penfield Determinative Mineralogy and Blowpipe Analysis, p. 131.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Properties of Liquid Nitrogen.*—Until recently it has been possible to experiment with liquid and solid nitrogen only upon a small scale, but since the gas is now a commercial article in Germany, where it comes compressed to about 100 atmospheres in a passably pure condition, H. Erdmann has taken the opportunity to study the liquid on a large scale. He employed a copper cylinder of about 1½ l. capacity which was provided with a manometer and had been tested to a pressure of six atmospheres. This was surrounded with liquid air and connected with the nitrogen bomb, so that the gas could be carefully introduced. The nitrogen could be condensed at an over-pressure of 0·7 atmosphere, while the condensation went on rapidly when this pressure reached 2 or 2½ atmospheres. The liquefied nitrogen was then transferred to a Weinhold-flask by means of a siphon valve. After filtration through a dry folded paper the liquid nitrogen was found to be a very mobile, clear, perfectly colorless liquid, which is decidedly different from the bluish colored liquid air. Since liquid air, even when freshly prepared, contains 50 to 60 per cent of oxygen, its specific gravity is so high that pieces of ice float upon it. On the other hand, ice sinks in liquid nitrogen, as does also solid absolute alcohol. The latter phenomenon agrees better with the specific gravity of liquid nitrogen determined by Ramsay and Drugman (0·7914 at the boiling-point), than with the determination of Dewar (0·850). When liquid nitrogen is poured upon a bulb filled with dry oxygen at atmospheric pressure, some of the oxygen is condensed in the form of bluish drops. This does not occur when liquid air is used. It is suggested that the easily prepared liquid nitrogen will be of service to chemists in producing somewhat lower temperatures than those obtainable with liquid air.—*Berichte*, xxxix, 1207. H. L. W.

2. *The Oxidation of Ammonia to Nitrates and Nitrites.*—The probable exhaustion in a short time of the South American nitrate beds makes it important to consider other means of producing nitrates and nitrites. The principal methods thus far suggested are the oxidation of atmospheric nitrogen and the oxidation of ammonia by the aid of contact substances. Since Germany possesses cheap water power in but few places, but has an abundant supply of ammonia from coal, the utilization of the second process appears to be of importance in that country. Schmidt and Böcker have, therefore, made some experiments with the oxidation of ammonia by atmospheric oxygen, using platinum and platinized asbestos as contact substances. They find as an average of many experiments a yield of from 75 to 76 per cent of the ammonia in the form of oxides of nitrogen, and in many cases a yield of over 80 per cent. It appears, however, that the process for producing nitrates cannot be carried out

profitably under the present condition of prices, but the production of nitrites from ammonia, by oxidizing it with air or oxygen in the presence of pyrites under certain conditions, according to a patented process of Bayer & Co., seems to be more promising.—*Berichte*, xxxix, 1366. H. L. W.

3. *The Detection and Determination of Small Quantities of Iron.*—A. Mouneyrat has found that the green color produced by passing hydrogen sulphide gas for about ten minutes through dilute, slightly ammoniacal solutions of iron salts is a much more delicate test than the familiar sulphocyanide reaction. It appears that the ferrous sulphide forms a colloidal solution when very little of it is present. The green color is discharged by concentrated solutions of ammonium and sodium sulphates and of sodium chloride, but many organic substances such as glycerine, sugars, tartrates, etc., increase the stability of the solutions and make it possible to obtain stronger ones. The limit of the delicacy of the reaction is about one part of iron in a million, when it is carried out in the manner just described, but the delicacy can be made greater by adding four or five milligrams of albumen to the ammoniacal solution, saturating with hydrogen sulphide as usual, then mixing with an equal volume of alcohol and allowing the liquid to stand ten or twelve hours. A green film is then found at the bottom of the vessel, due to the precipitation of a part of the albumen. It is stated that small quantities of mercury, lead, silver, chromium, nickel do not interfere with the reaction, although copper does so. The green colors obtained with amounts of iron varying from $\frac{1}{1000}$ to $\frac{1}{1000000}$ are practically proportional to the amounts, so that it is possible to make quantitative determinations in this way.—*Comptes Rendus*, cxlii, 1049. H. L. W.

4. *Quantitative Determination of Acetone.*—Adolph Jolles has devised a method for this purpose, which depends upon the combination of sodium bisulphite with acetone according to the equation

$$(CH_3)_2CO + NaHSO_3 = (CH_3)_2C{<}^{OH}_{SO_3Na}.$$

A titrated solution of bisulphite is added in such quantity that three or four times the required amount is present, and after standing 30 hours it is titrated back with iodine solution. Each molecule of bisulphite corresponds to a molecule of acetone. The reaction takes place slowly, and it was not found possible to shorten the time of standing. Test analyses gave very accurate results. They were made by mixing 25^{cc} of liquid containing about 0·05^{g} of acetone with 25^{cc} of $\frac{1}{5}$ normal bisulphite in a stoppered flask, then, after 30 hours, titrating back with $\frac{1}{10}$ normal iodine solution.—*Berichte*, xxxix, 1306. H. L. W.

5. *Avogadro and Dalton; the Standing in Chemistry of their Hypotheses;* by Andrew N. Meldrum; 8vo, pp. 113. Edinburgh, 1906 (James Thin).—This is a very interesting essay dealing chiefly with the relative importance of the atomic and molecu-

lar chemical theories. The argument is in favor of the greater value of Avogadro's contribution to science, while the admirers and followers of Dalton are criticized for giving him undue credit. All who are interested in the history of chemistry will find the book instructive, even though they fail to agree entirely with its conclusions; for it is ably written and displays much knowledge of the literature of the subject. H. L. W.

6. *Electric Discharge in Gases.*—Faraday supposed that an electric discharge occurs as soon as a determined discharge potential is reached which is sufficient to break down the dielectric. This theory takes no account of polar differences.

O. Lehman has sought to reconcile Faraday's theory with the facts by the assumption of a dark convective streaming which occurs before the discharge; and which on account of the different discharge, fitness of positive and negative air, leads to the formation of a positive air envelope at the cathode. J. J. Thomson, in an electrolytic theory, supposes that before the occurrence of the discharge a convective dark current is formed.

H. Sieveking, following the example of O. Lehman, has employed vessels of large size in studying the question of the existence of such dark currents. Lehman showed that the cathode space is much influenced by the nearness of the walls of the exhausted vessel to the cathode; he accordingly used exhausted vessels of 60 liters capacity.

Sieveking sums up his conclusions as follows:

(1) An investigation with a vessel enclosing an electroscope suitably charged showed that a dark current did not exist before the discharge. This is against the electrolytic hypothesis. Furthermore the insulation of the exhausted space below the point of discharge was perfect. A dissipation of electricity which must accompany a dark current could not be shown by an electrometer.

(2) In wide exhausted vessels the dark space is not influenced by a strong ionizing substance. This fact militates against the supposition of the electrolytic theory that this region is a poverty stricken one.

(3) The experiments indicate that the double layer which O. Lehman supposed to exist before the occurrence of the discharge does not exist.

(4) The very weak current which J. Elster and H. Geitel have shown to exist in air, and upon which Kaufmann founded the characteristics of the dark current, are not present in a space protected from ionization. The entire investigation leads one to believe in a pure disruptive discharge.

(5) The remarkable effect of the magnetic field on the electric discharge leads one to conclude with O. Lehman, from the standpoint of the electron theory, that powerful inner movements occur in the molecules which, through rotary movements, greatly influence the effect of the electric field.—*Ann. der Physik*, No. 7, pp. 209–226, 1906. J. T.

7. *Note on the computed drop of pressure in adiabatic expansion;* by C. BARUS.—I have hitherto expressed my results for the distribution of colloidal and other nuclei in a gas in terms of the observed fall of pressure δp in the fog chamber. If under isothermal conditions p is the pressure of the fog chamber, p' the pressure of the vacuum chamber and p_2 the common pressure after exhaustion of the former, $\delta p = p - p_2$. Recently I computed the actual fall $\Delta p = p - p_2$, where p_2 is the true isothermal pressure in the fog chamber isolated from the vacuum chamber immediately after exhaustion. The results are $\delta p - \Delta p = \cdot 225\ \delta p$, nearly.

Naturally I expected some appreciable correction in the final reduction, but I did not anticipate so large a difference. The result, however, is very interesting, for on applying it I find that the distribution curves obtained in the use of very large fog chambers now practically coincides with the curve which I deduced from the data obtained by Wilson with his small and unique apparatus. It appears furthermore that the successive improvements which I have added to my fog chamber have for some time reached a limit, and that its true efficiency is greatly in excess of my estimate.

8. *Meteorologische Optik;* von J. M. PERNTER. Mit zahlreichen Textfiguren. III Abschnitt: Seite 213–558. Wien und Liepzig, 1906 (Wilhelm Braumüller).—The opening section of this important work was noticed in this Journal several years since (see vol. xiii, p. 472), and now the third part is issued. It discusses a very interesting series of phenomena, namely, those due to the presence of minute foreign particles in the upper atmosphere. Many different forms of halos and of coronas are described and figured as well as discussed from a theoretical standpoint; in relation to these phenomena the varied forms of snow and ice crystals are described in detail. The subject of rainbows is very fully treated and illustrated. Altogether the work is a very important contribution to our knowledge of a peculiarly interesting but difficult subject.

9. *Leitfaden der Wetterkunde gemeinverständlich bearbeitet;* von Dr. R. BÖRNSTEIN. Zweite umgearbeitete und vermehrte Auflage. Pp. 230, with 22 tables. Braunschweig, 1906 (Friedrich Vieweg & Sohn).—After an interval of five years, the author has brought out a second edition of his elementary work on Meteorology. This is an indication of the success that the book has had in meeting the needs of those for whom it was expressly designed. The author states, as the fundamental principle present in his mind, that any person may, if properly instructed, become his own weather prophet, and with this before him he has endeavored to treat the whole subject in such a manner as to make it as intelligible as possible. This he has accomplished with marked success, but it still remains true that the subject is one not without difficulty, and requiring much study for even superficial mastery. Some of the new points introduced into this edition concern the relation of the temperature of the

air to water and forest, the heat movement in the ground, and observations above the earth by means of balloons and other methods; the discussion of the phenomena of atmospheric electricity has been rewritten.

10. *Refraktionstafeln;* von Dr. L. DE BALL, Direktor der v. Kuffnerschen Sternwarte. Pp. xiv, with 11 tables. Leipzig, 1906 (Wilhelm Engelmann).—The tables here included are based upon Radau's theory of refraction; the refraction constant assumed is that of Bauschinger, namely, $60''{\cdot}15$ for normal conditions of pressure in temperature and at sea-level at a latitude of 45°. There are eleven series of tables, and the special mathematical sources upon which they are based are explained in the Introduction, which is printed both in German and French.

11. *Shaft Governors;* by W. TRINKS and C. HOUSUM. Pp. 11, 97, with 27 figures and 16 tables. Van Nostrand Science Series, No. 122. New York, 1905 (D. Van Nostrand Co.).—This recent addition to the Van Nostrand Science Series will be properly valued by those who have to do with the use of shaft governors in practical machinery.

II. GEOLOGY AND MINERALOGY.

1. *Preliminary Report of the State Earthquake Investigation Commission;* 17 pp. Berkeley, May 31.—The Governor of California, on April 21, 1906, appointed a commission to examine and report on the phenomena connected with the earthquake which occurred three days previously at San Francisco. The members of the Commission are as follows: A. C. Lawson, of the University of California; G. K. Gilbert, of the U. S. Geological Survey; H. Fielding Reid, of Johns Hopkins University; J. C. Branner, of Stanford University; A. O. Leuschner and George Davidson, of the University of California; Charles Burkhalter, of the Chabot Observatory, and William Wallace Campbell, Director of the Lick Observatory.

In the preliminary report it is stated that the plane of dislocation was along the well-known fault-line which extends in a remarkably straight line obliquely across the Coast Range from Point Arena to Mount Pinos in Ventura County, a distance of 375 miles. This physiographic line "affords every evidence of having been in past time a rift, or line of dislocation, of the earth's crust and of recurrent differential movement along the plane of rupture. The movements which have taken place along this line extend far back into the Quaternary period, as indicated by the major, well-degraded fault scarps and their associated valleys; but they have also occurred in quite recent times, as is indicated by the minor and still undegraded scarps. Probably every movement on this line produced an earthquake, the severity of which was proportionate to the amount of movement."

"The earthquake of the 18th of April, 1906, was due to one of these movements. The extent of the rift upon which the move-

ment of that date took place is at the time of writing not fully known. It is, however, known from direct field observations that it extends certainly from the mouth of Alder Creek near Point Arena to the vicinity of San Juan in San Benito County, a distance of about 185 miles. The destruction at Petrolia and Ferndale in Humboldt County indicates that the movement on the rift extended at least as far as Cape Mendocino, though whether the rift lies inland or offshore remains as yet a matter of inquiry. Adding the inferred extension of the movement to its observed extent gives us a total length of about three hundred miles. The general trend of this line is about N. 35° W., but in Sonoma and Mendocino counties it appears to have a slight concavity to the northeast, and if this curvature be maintained in its path beneath the waters of the Pacific it would pass very close to and possibly inside of Capes Gordo and Mendocino. Along the 185 miles of this rift where movement has actually been observed the displacement has been chiefly horizontal on a nearly vertical plane, and the country to the southwest of the rift has moved northwesterly relatively to the country on the northeast of the rift. By this it is not intended to imply that the northeast side was passive and the southwest side active in the movement. Most probably the two sides moved in opposite directions. The evidence of the rupture and of the differential movement along the line of rift is very clear and unequivocal. The surface soil presents a continuous furrow generally several feet wide with transverse cracks which show very plainly the effort of torsion within the zone of the movement. All fences, roads, stream courses, pipe lines, dams, conduits, and property lines which cross the rift are dislocated. The amount of dislocation varies. In several instances observed it does not exceed six feet. A more common measurement is eight to ten feet. In some cases as much as fifteen or sixteen feet of horizontal displacement has been observed, while in one case a roadway was found to have been differentially moved twenty feet. Probably the mean value for the amount of horizontal displacement along the rift line is about ten feet and the variations from this are due to local causes such as drag of the mantle of soil upon the rocks, or the excessive movement of soft incoherent deposits. Besides this general horizontal displacement of about ten feet, there is observable in Sonoma and Mendocino counties a differential vertical movement not exceeding four feet, so far as at present known, whereby the southwest side of the rift was raised relatively to the northeast side, so as to present a low scarp facing the northeast. This vertical movement diminishes to the southeast along the rift line and in San Mateo County is scarcely if at all observable. Still farther south there are suggestions that this movement may have been in the reverse direction, but this needs further field study.

"As a consequence of the movement it is probable that the latitudes and longitudes of all points in the Coast Ranges have been permanently changed a few feet, and that the stations occupied

by the Coast and Geodetic Survey in their triangulation work have been changed in position. . . .

"The great length of the rift upon which movement has occurred makes this earthquake unique. Such length implies great depth of rupture, and the study of the question of depth will, it is believed, contribute much to current geophysical conceptions.

"The time of the beginning of the earthquake as recorded in the Observatory at Berkeley was 5 h. 12′ 6″ A. M., Pacific standard time. The end of the shock was 5 h. 13′ 11″ A. M., the duration being 1′ 5″. Within an hour of the main shock twelve minor shocks were observed by Mr. S. Albrecht of the Observatory and their time accurately noted. Before 6 h. 52′ P. M. of the same day thirty-one shocks were noted in addition to the main disturbance. These minor shocks continued for many days after April 18, and in this respect the earthquake accords in behavior with other notable earthquakes in the past. The minor shocks which succeed the main one are interpreted generally as due to subordinate adjustments of the earth's crust in the tendency to reach equilibrium after the chief movement."

The destructive effects of the earthquake are in the main distributed with reference to the line of rift, and are evident over an area approximately 50 by 400 miles. Within this area the intensity of the shocks varied greatly in accordance with topographic position and the character of the underlying rocks. The facts indicate an "excessively destructive effect of the earth wave as transmitted by the little coherent formations of the valleys bottoms."

A discussion of the geological problems presented by the earthquake is left for a more exhaustive report.

2. *United States Geological Survey*, CHARLES D. WALCOTT, Director.—The titles of publications recently received are given in the following list (see vol. xxi, 251, March, 1896): notices of some of these follow later.

Third Annual Report of the Reclamation Service. 1903–4. (Second Edition.) F. H. NEWELL, Chief Engineer. Pp. 653, with 59 plates in separate cover.—The Act of Congress, looking forward to the reclamation of the arid lands in the Western States and Territories, was passed in June, 1902. Since then three reports of the Reclamation Service connected with the Survey have been published; the last of which, in revised form, has recently been given to the public. It gives a summary of the various extensive operations planned, and shows that when they are brought to completion the results will be of the highest importance, not only for the regions involved, but for the country at large.

TOPOGRAPHIC ATLAS.—Twenty-seven sheets.

FOLIOS: No. 130. Rico Folio: Colorado. Description of the Rico Quadrangle; by WHITMAN CROSS and F. L. RANSOME: Geography and General Geology of the Quadrangle by WHITMAN CROSS. Pp. 20, with 5 colored maps and 6 figures.

No. 131. Needle Mountains Folio : Colorado. Description of Needle Mountains Quadrangle by WHITMAN CROSS, ERNEST HOWE, J. D. IRVING, and W. H. EMMONS. Topography and General Geology by WHITMAN CROSS and ERNEST HOWE. Pp. 13, with 4 colored maps and 11 figures.

No. 132. Muscogee Folio : Indian Territory. Description of the Muscogee Quadrangle ; by JOSEPH A. TAFF. Pp. 7, with 3 colored maps.

No. 133. Ebensburg Folio : Pennsylvania. Description of the Ebensburg Quadrangle ; by CHARLES BUTTS. Pp. 9, with 4 colored maps.

No. 135. Nepesta Folio. Colorado. Description of the Nepesta Quadrangle ; by CASSIUS A. FISHER. Pp. 5, with 3 colored maps.

No. 136. St. Mary's Folio : Maryland—Virginia. Description of the St. Mary's Quadrangle; prepared, under the supervision of WILLIAM BULLOCK CLARK, geologist-in-charge, by GEORGE BURBANK SHATTUCK. Pp. 7, with 2 colored maps.

No. 137. Dover Folio : Delaware—Maryland—New Jersey. Description of the Dover Quadrangle ; prepared under the supervision of WILLIAM BULLOCK CLARK, geologist-in-charge, by BENJAMIN LEROY MILLER. Pp. 10, with 2 colored maps.

MONOGRAPHS.—Atlas to accompany Monograph XXXII on the Geology of the Yellowstone National Park ; by ARNOLD HAGUE, Washington, 1904.

This atlas, recently published, contains twenty-three beautifully executed maps, giving in detail the topography and geology of the Yellowstone region. The text, which this atlas illustrates, was issued several years since and then noticed in this Journal. (See vol. ix, p. 297.)

PROFESSIONAL PAPERS.—No. 44. Underground Water Resources of Long Island, New York; by A. C. VEATCH, C. S. SLICHTER, ISAIAH BOWMAN, W. O. CROSBY and R. E. HORTON. Pp. 394, with 34 plates including several maps in pocket and 7 figures.

No. 45. The Geography and Geology of Alaska : A summary of Existing Knowledge; by ALFRED H. BROOKS ; with a Section on Climate, by CLEVELAND ABBE, JR.; and a Topographic Map and Description Thereof, by R. U. GOODE. Pp. 327, with 34 plates and 6 figures.

No. 47. The Tertiary and Quaternary Pectens of California; by RALPH ARNOLD. Pp. 264, with 53 plates and 2 figures.

No. 48. Report on the Operations of the Coal-Testing Plants of the U. S. Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904. EDWARD W. PARKER, JOSEPH A. HOLMES, MARIUS R. CAMPBELL, Committee in charge. Pp. 1492, with 13 plates and 135 figures. Part I, Field Work, Classification of Coals, Chemical work. Pp. 1–300. Part II, Boiler Tests. Pp. 301–980. Part III, Producer Gas, Coking, Briquetting, and Washing Tests. Pp. 981–1492.

No. 49. Geology and Mineral Resources of Part of the Cumberland Gap Coal Field, Kentucky; by GEORGE HALL ASHLEY and LEONIDAS CHALMERS GLENN, in cöoperation with the State Geological Department of Kentucky, C. J. NORWOOD, Curator. Pp. 239, with 40 plates, 13 figures and two pocket maps.

BULLETINS.—No. 269. Corundum, its Occurrence and Distribution in the United States; by JOSEPH HYDE PRATT. Pp. 176, with 18 plates and 26 figures. This is a revised and enlarged edition of Bulletin No. 180.

No. 274. A Dictionary of Altitudes in the United States. Fourth edition; compiled by HENRY GANNETT. Pp. 1072.

No. 280. The Rampart Gold Placer Region, Alaska; by L. M. PRINDLE and FRANK L. HESS. Pp. 54, with 7 plates and 1 figure.

No. 281. Results of Spirit Leveling in the State of New York for the years 1896 to 1905 inclusive; by S. S. GANNETT and D. H. BALDWIN. Pp. 112.

No. 282. Oil Fields of the Texas-Louisiana Gulf Coastal Plain; by N. M. FENNEMAN. Pp. 146, with 11 plates and 15 figures.

No. 288. Results of Spirit Leveling in Pennsylvania for the years 1899 to 1905 inclusive; by S. S. GANNETT and D. H. BALDWIN. Pp. 62.

WATER-SUPPLY AND IRRIGATION PAPERS.—No. 148. Geology and Water Resources of Oklahoma; by CHARLES NEWTON GOULD. Pp. 178, with 22 plates and 32 figures.

No. 153. The Underflow in Arkansas Valley in Western Kansas; by CHARLES S. SLICHTER. Pp. 90, with 3 plates and 24 figures.

No. 154. The Geology and Water Resources of the Eastern Portion of the Panhandle of Texas; by CHARLES N. GOULD. Pp. 64, with 15 plates and 4 figures.

No. 157. Underground Water in the Valleys of Utah Lake and Jordan River, Utah; by B. RICHARDSON. Pp. 76, with 9 plates and 5 figures.

Nos. 134, 165, 166, 167, 168, 169, 171. Report of Progress of Stream Measurements for the Calendar year 1905. Prepared under the direction of F. H. NEWELL. Parts I–V, VII, XI.

3. *Pleistocene Geology of Mooers Quadrangle;* by J. B. WOODWORTH. Bulletin 83 New York State Museum, pp. 60, with Bibliography and Index. One geologic map and 25 plates.

Ancient Water Levels of the Champlain and Hudson Valleys; by J. B. WOODWORTH. Bulletin 84, N. Y. State Museum, pp. 265, with Bibliography and Index. One geologic map and 28 plates. Published by the New York State Education Department, Albany, New York, 1905.—An examination of the published maps depicting late Pleistocene events will show that one of the latest phases, that of ice withdrawal from the Champlain and lower St. Lawrence valleys, has been least perfectly understood. The question of marine invasion subsequent to such with-

drawal and its relation to the glacial attitude of the land and postglacial changes of level have been inferred from rather too widely scattered data; and the conclusions thus reached were perforce somewhat contradictory. The situation required extended and detailed investigation of the field from Manhattan to the St. Lawrence.

The distinguishing features of Prof. Woodworth's reports on this area are their clear and dispassionate discussion of the hypothesis of glacial retreat in a narrow valley and of the formation of associated marginal deposits (pp. 79–86, No. 84); and the interpretation of complex deposits over an extended field. In these respects the reports are justly comparable to Leverett's Monographs on the glacial history of the Great Lakes region.

To the student of glacial geology the method of work is quite as interesting as the conclusions. It is found that the form of the Hudson Valley influenced the retreat of the ice so strongly that it is possible to outline the history of glacial retreat in terms of the varying cross-section of the valley, taking into account the order and arrangement of the deposits made either by ice or tributary streams. In the Champlain region the evidence collected is chiefly from the New York side of the lake and consists of moraines, dry gorges and falls, spillways, beaches, bars, wave-cut cliffs and benches, and marine shells.

While the conclusions are based on a limited amount of field work and cannot therefore be regarded as final on account of the great extent of the field and the complexity of the details, they nevertheless have a high value because of the discriminating choice of sites critically examined for decisive evidence. I. B.

4. *Geology and Water Resources of Oklahoma;* by CHARLES NEWTON GOULD. Water-Supply and Irrigation Paper No. 148. Pp. 178, with 32 plates and 32 figures. U. S. Geol. Survey. Washington, 1905.—This report is as much of a geologic nature as hydrographic and as such should be called to the attention of geologists. The Wichita mountains in the southern part of the territory consist of Archean and Lower Paleozoic formations and are completely surrounded by Permian strata. The lower of these "Red Beds" are believed to correspond chronologically with Carboniferous limestones in Kansas. Many sections are given showing the gypsum beds, and Prof. Gould believes the Permian here to be wholly marine. The Tertiary deposits of the High Plains and their relation to water supply are also discussed.

J. B.

5. *Bulletins of the Geological Survey of Virginia;* THOMAS L. WATSON, Geologist in charge. No. II. The Clay Deposits of the Virginia Coastal Plain, by HEINRICH RIES; with a chapter on The Geology of the Virginia Coastal Plain by WILLIAM BULLOCK CLARK and BENJAMIN LE ROY MILLER. Pp. 184, with 15 plates. Board of Agriculture and Immigration, 1906.—This is a thorough account of the clay occurrences and industry of Virginia, rendered more interesting from the introduction on the general geology of the Coastal Plain.

No. III. Hydrography of Virginia; by N. C. GROVER and R. H. BOLSTER. Pp. 234, with 10 plates and 1 text-figure. This Bulletin discusses the drainage basins of the prominent rivers of Virginia,—namely, the Potomac, the James, the Roanoke, and New River. A drainage map of the state showing gaging and rainfall stations is given, and a large amount of data are presented for the individual rivers.

6. *La Sierra de Cordoba: Constitucion geologica y Productos minerales de aplicacion;* by W. BODENBENDER. Rep. Argentina An. d. Ministerio d. Agric. Sec. Geol., Tom. I, Num. II, 1905. 8°, 150 pp.—The Sierra de Cordoba lies between 21° and 23° S. and 63½° and 65° W. in Argentina with a general north and south direction and is composed of several ranges, some of whose peaks have altitudes from 6–8000 feet. The memoir is devoted first to a general geological description of the area, aided by a geological map. Then follows a list of occurrences of minerals, of which a large number of species are mentioned. The rocks are then treated and brief petrographic descriptions of the different kinds are given, both of the crystalline schists and igneous rocks. The sedimentary rocks are conglomerates, sandstones, etc., of Cambrian and supposedly Silurian age and of the Permian-Triassic, with argillaceous beds of the Pampas terrane. The work concludes with a brief account of the economic mineral deposits. It is illustrated by a considerable number of halftone cuts of photographs illustrating various features of interest in the mountain region. The work is more or less general and preliminary in character, yet contains in compact form a great deal that is of interest and importance concerning a little known region. L. V. P.

7. *Contributions from the Geological Department of Columbia University.* Vol. xii, Nos. 107, 108. Vol. xiii, Nos. 109–114. —These include numerous geological papers, published by gentlemen connected with Columbia University in various journals and society transactions, and now collated, in convenient form for binding, in sequence with similar volumes previously distributed.

8. *The Constitution of the Silicates.* — In a paper on the Chemical Constitution of the Feldspars, presented to the Vienna Academy in 1903, Professor TSCHERMAK undertook to throw light on the chemical composition of the feldspars, especially with reference to the particular type of silicic acid present. From the slow decomposition of the mineral by hydrochloric acid a hydrated silicic acid is separated which, when exposed to the air, rapidly loses water for a number of days, but finally passes into a condition where the further loss is very slow, except upon ignition. By determining the amount of water present at the point named, the author believes that he establishes the constitution of the silicic acid present. For anorthite, for example, the loss of water by ignition was found to be 23·41, while the acid H_2SiO_3 requires 22·98. The conclusion is reached, therefore,

that anorthite is to be regarded, not as an orthosilicate, but as a metasilicate. Later papers on the same general subject (Sitzungsberichte Akad. Wien cxiv(i), 455, 1905, cxv(i) Feb., 1906), discuss the matter in more detail. The conclusion is reached that while willemite and monticellite are to be regarded as orthosilicates, olivine is a metasilicate, and the acid present in garnet, epidote, zoisite and prehnite is $H_4Si_3O_8$; the formula of olivine would be written $(MgOMg)SiO_3$.

9. *An Introduction to Chemical Crystallography;* by P. GROTH, Authorized Translation by HUGH MARSHALL. Pp. vii, 123. New York, 1906 (John Wiley & Sons).—The Chemical Crystallography of Professor Groth was noticed about a year since when the German edition was issued (see vol. xix, p. 467). We have now an authorized English translation made by Dr. Hugh Marshall of the University of Edinburgh. This will be found very useful by the English-speaking public and will extend the sphere of usefulness of this valuable work. The translation has been prepared in coöperation with the author, who has supervised the proof-sheets. It follows the original closely and adds occasional references to original papers or abstracts which have appeared in the Journal of the Chemical Society.

10. *Geometrische Kristallographie;* by ERNST SOMMERFELDT. Pp. 139, with 31 Tafeln and 69 text-figures. Leipzig, 1906 (Wilhelm Engelmann).—Those interested in the problems of modern crystallography, handled particularly from the theoretical side, will find much of value in the present work. A series of thirty-one ingeniously constructed plates at the close of the volume present, in a novel way, the symmetry conditions and the relations of the existing forms to each other.

11. *Étude sur l'État actuel des Mines du Transvaal: Les Gites—Leur Valeur, Étude industrielle et financière;* by GEORGE MOREAU. Pp. 218, with 48 figures. Paris, 1906 (Librairie Polytechnique, Ch. Béranger, Editeur).—This is a useful work to those interested in the mines of South Africa, giving a description of the country and its geology with particular reference to the Witwatersrand; a full discussion of methods of exploitation adopted is added. The author speaks enthusiastically of the mineral resources of the Transvaal and its possibilities, although he recognizes some of the limitations to its development which unavoidably exist.

12. *Anleitung zum Gebrauch des Polarisationsmikroskops;* von Dr. ERNST WEINSCHENK. Pp. vi, 147, with 135 figures. Zweite, umgearbeitite und vermehrte Auflage. Freiburg im Breisgau, 1906. (Herdersche Verlagshandlung. Zweigniederlassungen in Wien, Strassburg, München, und St. Louis, Mo.)—An excellent presentation of the polarization microscope in its different parts, with the various methods of investigation applicable to it and the principles involved in their use. It is well illustrated and gives, in small compass, just the information needed by students of the subject. It should be in the hands of every one concerned with this field of investigation.

13. *Tabellen zur mikroskopischen Bestimmung der Mineralien nach ihrem Brechungsindex;* von Dr. J. L. C. SCHROEDER VAN DER KOLK. Zweite umgearbeitete und vermehrte Auflage; von E. H. M. BEEKMAN. Pp. vi, 68 with folded plate. Wiesbaden, 1906 (C. W. Kreidel).—The first edition of these useful tables was issued in 1900 and noticed in volume ix, p. 229, of this Journal. The tables have been rearranged and increased in size by Dr. Beekman, and in their new form will unquestionably prove still more valuable to those interested in microscopic mineralogy. The preparation of this new edition was undertaken in order to carry out the plan of the author, who died on June 17, 1905; it consequently follows the lines laid down by him.

14. *Minéralogie des Départements du Rhone et de la Loire;* par FERDINAND GONNARD. Pp. 122, with 31 text-figures. 1906. Lyon (A. Rey) and Paris (J. B. Baillière & Fils). Annales de l'Université de Lyon. Nouvelle Série: I. Sciences, Médecine, Fascicule 19.—This is an account of the mineral species which occur in two of the departments of France particularly rich in this direction. Among the most conspicuous species may be mentioned the azurites of Chessy, the zeolites of Mt. Simiouse, the calcite of Couzon and the cerussites of Pacaudière. The work is a valuable supplement to the more exhaustive treatises on mineralogy.

15. *Studien über Meteoriten, Vorgenommen auf Grund des Materials der Sammlung der Universität Berlin;* von C. KLEIN. Aus den Abhandlungen des Königl. Preuss. Akademie der Wissenschaften vom Jahre, 1906. Pp. 141, with three plates. Berlin, 1906.—The meteorite collection of the University of Berlin has always been a classical one ever since the time of Gustav Rose. For many years, however, the collection did not grow adequately, and it is only since Professor Klein took hold of the matter that it has regained its relative importance among the great collections of the world. In 1887, there were 213 localities represented, and now in 1906 the number has increased to 500. This publication is much more than a mere catalogue of the specimens represented, for it also gives a description of meteorites in general, with a special account of certain important examples. One of the most interesting of these has been earlier described by the same author, namely the leucituranolite of Schafstädt.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Plaster-plaques for Museums;* by GEORGE LINCOLN GOODALE (Communicated).—The fine finish of a properly made plaster mount renders it preferable to slate or ground glass or polished wood, for specimens which require a firm support and a good contrasting surface. The excellent mounts which have been made by the Dentons show clearly the adaptability of plaster for even the most delicate and brilliant organisms. The problem in our Museum was to provide a mount which should answer not

only for very fragile and delicate specimens, but would at the same time serve to keep in perfect position specimens of considerable weight and size. It was imperatively necessary to secure such specimens from even the slightest bending.

The Blaschka glass models of plants in flower are shipped to our Museum fastened to a firm cardboard which answers every purpose as a permanent mount for the smaller species. But even when re-enforced by strips of wood, the larger plates of cardboard have a tendency to curve, sometimes in more than two directions, and this curvature seemed likely to put the larger models in some peril of breaking.

Acting on a suggestion of Dr. Libbey of Boston, an attempt was made, about six years ago, to substitute plaster-plates for the heavy cardboard. More than a year was consumed in fruitless experimenting. The small plates were fairly strong and for the most part, satisfactory, but the larger ones, say from two feet square and upward, were untrustworthy and therefore of no use in our cases.

Fortunately, at the time when our experiments were on the eve of abandonment, there was in the service of the Museum an expert cabinet-maker who expressed a desire to undertake a continuation of the work along a different line. After a few trials which varied in success, he was able to produce plaques of high finish and great density. Tests showed that these new plaques were sufficiently strong to bear any weight to which it was likely they could ever be subjected, and moreover, they did not show the least tendency to bend. About fifty were made four years ago, and, after they had been exposed to all reasonable risks, it was found that they had not sustained any permanent injury of any sort. During the last three years, more than seven hundred plates have been successfully made, and these are now installed in the exhibition rooms of the botanical section of the Museum. They are so strong, so free from curvature and so attractive in general appearance, that they appear to answer every requirement as mounts.

The following is the method of their manufacture:

(1) The appliances. On a stout table perfectly levelled there is placed a plate of the finest plate-glass of the required size. On our tables we have used glass of a convenient size for our work, namely four by three feet, and five by four feet. Care is taken to choose only "first" plate: "seconds" are likely to have small blow-holes or slight curvatures. For each plate on the table another of equal size and of about the same thickness is placed near at hand.

In order to form a dam around the sides of the glass, to prevent the plaster from running off, we have used strips of wood of just the thickness of the desired plaque. These are simply put in place and not fastened to the glass in any way.

(2) The liquid plaster is made in the following way: into a large pail of perfectly clear soft water, enough fine plaster of

Paris is quickly sifted in, with constant stirring, until the mass becomes of the proper density.

(3) The liquid mass is now poured rapidly without the formation of any bubbles upon the surface of the glass on the table, filling all the space between the strips of wood. Then as quickly as possible, the other plate of glass is put over the liquid, great care being taken that no bubbles creep in, and then heavy weights are put on this glass, pressing out all excess of liquid plaster. In the course of fifteen or twenty minutes, depending on conditions not yet thoroughly understood, the upper glass can be separated from the plaque, by gradual lifting at one side.

In ten or fifteen minutes more, the plaque can be separated from the floor glass. At this time, a small hole is to be made in one corner, about an inch and a half from the edge; this serves for hanging the plaque on a nail in a dry room. The drying takes place slowly in winter, but in summer the whole sheet will be thoroughly dry in a few days.

The plate can now be cut into any desired shape and size by a simple device. First, make a deep scratch in the plaster where the break is desired, and then break exactly as a square of glass is cut. When the break has been made, the edge is finished by means of a plane, and it can be bevelled also, if necessary.

If the surface has too glossy a finish, reduce the luster by a common stiff brush carried evenly over the whole surface.

We have made many attempts to improve the color of the plaques by the addition of various fine pigments, but the effect has always been unsatisfactory. The color tints with a little Prussian-blue, and the warmer tints with a very little vermillion, were liked by many, but as a rule, the plain undazzling white has been found best.

We are now employing plaques of this sort also for our cases in which we are installing specimens of seeds, fruits, etc., which are better exhibited without any covering at all. In this way, for instance, specimens illustrating dissemination are placed before the public in a very attractive manner. The contrast between the specimen and the pure white plaster mount is in no instance unpleasing.

Cambridge, June, 1906.

2. *The American Association for the Advancement of Science.*—The special summer meeting of the American Association will be held in Ithaca, New York, from June 28th to July 3d. Several Societies, including the American Physical Society and the American Chemical Society, are to meet at the same time in affiliation with the Association. Professor William H. Welch, of Baltimore, is the President of the Association for the Ithaca meeting, and the Vice Presidents of the several sections are given in the following list: Section A, Mathematics and Astronomy: Edward Kasner, Columbia University; B, Physics: W. C. Sabine, Harvard University; C, Chemistry: Clifford Richardson, New York City; D, Mechanical Science and Engineering: W. R. Warner, Cleveland; E, Geology and Geography: A. C.

Lane, Lansing, Mich.; F, Zoology : E. G. Conklin, University of Pennsylvania; G, Botany: D. T. MacDougall, Carnegie Institution, Washington ; H, Anthropology : Hugo Münsterberg, Harvard University ; I, Social and Economic Science: Chas. A. Conant, New York, N. Y.; K, Physiology and Experimental Medicine: Simon Flexner, Rockefeller Institute, New York.

3. *Memoirs of the National Academy of Sciences.* — The fourth memoir of Volume X has recently been issued; the subject is: Phoronis Architecta, Its Life History, Anatomy, and Breeding Habits, by William Keith Brooks and Rheinart Parker Cowles. Pp. 75–148, with 17 plates.

4. *Zeitschrift für Gletscherkunde, für Eiszeitforschung und Geschichte des Klimas.* Organ der Internationalen Gletschercommission ; herausgegeben von Eduard Brückner. Band I, Heft 1, pp. 80. Berlin, 1906 (Gebrüder Borntraeger).—A new journal devoted to Glaciology has recently been inaugurated as the organ of the International Glacial Commission, with Dr. Eduard Brückner as editor. He will be assisted by eleven associate editors ; the American representative is Dr. H. F. Reid, of Baltimore. The journal will contain discussions of subjects relating to glaciology and the investigation of the Ice Age in all its phases, with shorter communications on the same subjects, reviews of books and papers published elsewhere, and a general bibliography. It will be international in character; while the editorial matter will be in German, the papers and communications may be in any one of the four prominent languages. It will be issued at irregular intervals, not more than five parts annually, each part containing 80 pages octavo ; subscription price, sixteen marks. The first number has just been distributed and bears the date of May, 1906. This new journal fills an important gap in the series of special scientific organs, and will doubtless accomplish much in promoting interest in the subjects with which it deals ; it should receive liberal support.

5. *Publications of the Field Columbian Museum, No. 109, Geological Series, Vol. iii, No. 2.* The Shelburne and South Bend Meteorites; by Oliver Cummings Farrington. Pp. 23, with 15 plates.—The account of the Shelburne meteorite as described by Borgström was given in the January number of this Journal (p. 86). Dr. Farrington now describes a second stone of the same fall weighing 12¼ pounds. Its fall was quite unusual, since it came down in a narrow space between a house and a shed, narrowly escaping both of them, and burying itself 18 inches in the ground. The South Bend meteorite, also described in this pamphlet, is a pallasite weighing 5½ pounds, and was found in 1893 two miles from South Bend, in St. Joseph county, Indiana. This is the seventh pallasite which has been discovered in the United States; it is referred to the Imilac group and the ratio of nickel-iron to chrysolite is 21·4 to 78·6.

No. 110, Geol. Series, Vol. ii, No. 7. The Carapace and Plastron of Basilemys sinuosus, a new Fossil Tortoise from the

Laramie Beds of Montana; by ELMER S. RIGGS. Pp. 249–256, with three plates.

6. *Carnegie Institution of Washington.*—The following are recent publications:

No. 49. Heredity of Hair-length in Guinea-pigs and its Bearing on the Theory of Pure Gametes; by W. E. CASTLE and ALEXANDER FORBES. Pp. 1–14. (No. 5 of Papers of the Station for Experimental Evolution at Cold Spring Harbor, N. Y.)

The Origin of a Polydactylous Race of Guinea-pigs; by W. E. CASTLE. Pp. 14–29 (No. 175 of Contributions from the Zoological Laboratory of the Museum of Comparative Zoology at Harvard College, E. L. Mark, Director).

No. 51. Studies on the Germ Cells of Aphids; by N. M. STEVENS. Pp. 28, with four plates.

7. *Personal Hygiene designed for undergraduates;* by ALFRED A. WOODHULL, A.M., M.D., LL.D. Pp. vii+221. New York (John Wiley & Sons), 1906.—This little book, the outcome of a course of lectures given to undergraduate students at Princeton, presents in simple language sound advice regarding the development and care of the body. A few introductory chapters briefly describing the general anatomy and physiology of the organ systems of the body are followed by chapters on physical culture, fatigue, elimination of waste, bathing, clothing, food, tobacco and alcohol. Careful reading of this book cannot fail to leave in the mind of the student a better appreciation of the common rules for hygienic living, and would in all probability increase his future health and happiness.

8. *The Bulletin of the Imperial Central Agricultural Experiment Station, Japan.* Vol. i, No. 1. Pp. 94. Nishigahara, Tokio, December, 1905.—Japan has already forty-seven independent agricultural experiment stations, and this new publication will serve to make public the results of the investigations carried on in them. The first number contains eleven articles, treating largely of the action of mineral substances on vegetable growth, or on bacterial action.

OBITUARY.

DR. ERNST SCHELLWIEN, Professor of Geology at Königsberg, died on May 14th in his fiftieth year.

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Our new Catalogue XIX, with many illustrations, has just come out (post free on application). Of its contents, the following may be mentioned:

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The new edition of *H. Rosenbusch text-book* (by H. Rosenbusch and E. A. Wülfing), Vol. I, "Mikroskopische Physiographie der Mineralien," has just come out in two parts, each of which contains a considerable number of photographic reproductions showing the microscopical features and structures of the rock-forming minerals. By the kindness of the author and publisher we have been able to prepare *lantern slides of the original photos*, which we now offer in two sets of 72 slides each; collection A, representing the figures on the plates IV–XV of part I; collection B, those of the plates I–XII of part II.

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We also remind the reader of the following collections of lantern slides:

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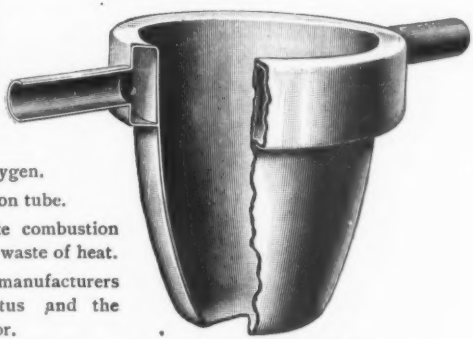

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